

A CONTINUING PROGRAM FOR TECHNOLOGY TRANSFER TO THE APPAREL INDUSTRY

FINAL REPORT

By William H. Clingman

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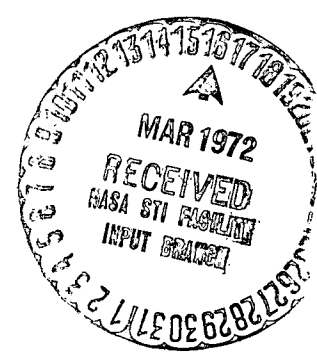
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FINAL REPORT

SUMMARY

A six month program has been carried out to investigate various mechanisms for transferring technology to industry. This program has focused on transfer to the apparel industry through the Apparel Research Foundation. The work was preceded by an initial program with that industry. In this initial program a set of operating guidelines was prepared for a technology application team that would be concentrating on transfer to small business. The project was reported in "Evaluation of the Team Approach for Technology Transfer to Small Business", prepared by W. H. Clingman & Co. for the Denver Research Institute under Contract No. NSR 06-004-063 with the National Aeronautics and Space Administration. This initial project essentially consisted of working with an industry organization on a selected problem. The procedure was to analyze the problem, obtain potentially relevant aerospace technology, and then transfer this technology to the industry organization. This was done in a specific case. Technology was identified relevant to stitchless joining, and this technology was transferred to the Apparel Research Foundation. The feasibility and ground rules for carrying out such activities on a broader scale were established.

A specific objective of the present program was to transfer new technology from the industry organization to the industry itself. In other words the objective was to stimulate action which would result in the above stitchless joining technology being made available to apparel manufacturers. This required the establishment of an application engineering program. The project has accomplished this, and the application engineering is being supported by industry. The documentation in this report also provides a good case study as to how some of the barriers to technology transfer to industry can be overcome with an application team approach.

Other objectives of this project were to continue to identify and transfer potentially relevant aerospace technology to the industry through the Apparel Research Foundation (ARF). A second problem, Automatic Fabric Guidance, was chosen by ARF. This problem was then analyzed and NASA generated technology relevant to it was identified. The technology was transferred to ARF in the form of a specially prepared report. Also a different mechanism for transfer was evaluated. Many NASA developments were screened for possible application to the industry. Short announcements were then prepared which focused on the industry problem and explained how the NASA technology was applicable. These announcements were written in a style familiar to management in the industry. They were then edited and distributed by ARF. The membership of ARF feels that this

is a useful service to them and some firms are evaluating specific items for application in their operations.

In this report the background for the project is first presented. This background includes a review of the previous program and the reasons for working with the apparel industry. Following the background section each of the three areas of activity under the project is described. First is the work on initiating application engineering on the stitchless joining problem. Second the identification of NASA technology relevant to automatic guidance is discussed. Finally the announcement series is described. Various conclusions have arisen out of the work with ARF for each of these activities. These conclusions are discussed in each of the following sections. In the final section of the report a set of recommendations to NASA is presented based on these conclusions. Included in the recommendations is a method for applying the team approach to technology transfer in other industries. Also included is a proposed method for continuing work with the Apparel Research Foundation where the industry itself supports most of the transfer activities required.

From the results of the study it was definitely concluded that there is a need for stimulating action in achieving technology transfer. This is required to get a firm to manufacture a product using the new technology identified and transferred to the industry association. The reason for this is primarily inertia. Usually either the firm manufacturing or using the new product would have to change their present method of operation. The advantages of such change will often not be recognized until a third party points them out. This is one type of "stimulating action". It was also concluded from the project results that such action can be successful.

Another transfer mechanism tested was publication of solutions to industry problems in a format familiar to the industry. This is to be distinguished from circulating descriptions of new technology. Focus is on the industry problem and the manager is given a formula for solving it that he can follow. It was concluded that this mechanism can complement the problem statement approach to technology transfer. It is useful in achieving transfer when a large amount of application engineering is not necessary. A wide audience is immediately exposed to the technology. On the other hand, the major manufacturing problems which require a sophisticated technical solution integrating many innovations are less likely to be helped.

INTRODUCTION

The project which preceded the present one was carried out to evaluate the team approach for technology transfer to small business. The project essentially consisted in working with an industry organization on a selected problem. The procedure was to analyze the problem, obtain potentially relevant aerospace technology, and then transfer this technology to the industry organization. In addition to effecting such transfer the purpose of the initial study was to demonstrate the feasibility of carrying out such activities on a broader scale. This was accomplished. The team approach was successfully applied to a single case. Many factors in the *modi operandi* for such a team were established. In particular, methods of problem definition and selection were evaluated. Aspects of these functions which differ from those of the present Biomedical and Technology Application Teams were studied. These factors were discussed in "Operating Guidelines, Technology Application Team For Transfer to Small Business", which was prepared as a part of the initial project.

The apparel industry was selected as one in which to work during this initial experimental project. This industry is dominated by small firms. Technological improvements in the manufacturing processes are needed to reduce the labor content of their products. This is required to better meet the growing competition from imports. Our contact with the apparel industry has been through the Apparel Research Foundation, Inc. This organization is entirely supported by the industry and sponsors research aimed at improving the manufacturing processes available to the industry. A premise in the project was that aerospace technology would be transferred to the industry through the programs and under the auspices of the Apparel Research Foundation (ARF).

The industry problem selected for study was entitled "Stitchless Joining". At the time of the study the Apparel Research Foundation had identified this as a problem of significance to the technological growth of the industry. A technical analysis of the problem was made in our study based on previous analyses submitted to us by the Apparel Research Foundation. The significance of the problem to manufacturers was also examined through interviews. After a problem statement was prepared, relevant aerospace technology was identified by both a computerized literature search and by circulating the problem statement to the NASA centers. A report was prepared for the Apparel Research Foundation which described this technology and discussed its significance to their program. As a result of this report, ARF took administrative steps toward modifying their program. That program had not fully considered the aerospace technology which was identified. The ARF staff decided to modify the program so that it would build on this existing technology. The ARF program would then do the application engineering necessary for the relevant aerospace technology to find practical application in the apparel industry.

In transferring technology to small business through an industry organization, chosen in this case as the vehicle to reach a fragmented industrial base, the technology must first be transferred to that organization. That is, the technical information is made available to them in such a form that they take some action as a result of receiving it. This was accomplished in the case of stitchless joining. After this, the technology must find its way into actual manufacturing practice. This often requires application engineering. It could also involve motivational factors which are somewhat different than those involved in the industry organization taking action. The type and extent of continuing action taken by the industry organization could be quite important in determining the length of time required for this second step.

An objective of the present project was to optimize this continuing action on the part of ARF. It was desired to hasten the industrial application of the aerospace technology which had already been transferred to ARF. The factors significant in motivating the industry to sponsor the required application engineering were studied in the present project.

In this regard there existed an opportunity which the NASA sponsored Biomedical Application Teams do not have. Transferring technology to a medical research group and having that group modify their program is analogous to transferring technology to ARF and having them modify their research program. At this point the Biomedical Application Team can do little more. They are usually not in a position to motivate the medical team so as to hasten the actual application of the technology to the curing of patients. It was our hypothesis that this would be possible in working with an industry organization. It was one purpose of the present program with ARF to accomplish this.

A second objective of the present project was to transfer technology to ARF in areas other than stitchless joining. A number of opportunities had been identified in the initial project for doing this. These included human factors engineering and automatic fabric guidance. Each is concerned with the effectiveness of the workers. The former was principally concerned with the placement of controls for the optimum operation of machines. Automatic fabric guidance was principally concerned with the problem of making a seam where the two pieces of fabric have nonmatching edges. A third problem significant to the industry is the utilization of waste cloth and minimizing the amount of waste generated. Of these problems ARF placed the highest priority on automatic fabric guidance. Specific NASA technology was thus sought in the present study applicable to this.

Another approach to transferring technology to the industry was pursued in the present project. It had been found in the initial project that there were some items of NASA developed technology that could be applied without application engineering. When the original NASA reports or Tech Briefs were sent to manufacturers, however, there was a negative response. They could not see the relevance of the aerospace technology to their problems. The reports focused on the technology. In the present project a special series of

announcements was prepared which focused on applications clearly relevant to the manufacturers' problems. These described how the manufacturer could apply specific NASA technology. They were distributed to firms that were members of ARF and feedback obtained as to their utility.

There were thus three areas of activity to be carried out under the present project. These involved initiating application engineering on stitchless joining, transferring to ARF technology relevant to automatic fabric guidance, and preparing a series of announcements of new technology. Each of these activities was approached in the manner of an experiment. Careful note was taken of the reaction of the industry and the industry organization to each step. Those factors which were significant to the successful transfer of technology were observed. Finally in each case a set of conclusions was derived on future activities for transferring aerospace technology to industry. Each of these three areas of activity are individually described in the next three sections of this report.

TRANSFER OF STITCHLESS JOINING TECHNOLOGY TO INDUSTRY

The objective of this part of the project was to optimize the transfer of stitchless joining technology from the Apparel Research Foundation to firms in the apparel industry. To accomplish this, activity continued with ARF regarding the application of aerospace technology to the stitchless joining problem. The purpose of this activity was to hasten the use of this technology by manufacturers in the industry. The nature of the activity could have originally taken a number of different possible forms. The program was an interactive one with ARF and each step taken was determined by their most recent actions and attitudes regarding the stitchless joining project. In fact, it was from this interaction that insight was gained into the significant motivational factors during the application engineering phase.

Technology relevant to stitchless joining had been located in four different areas in the previous project. These were: (1) surface treatment of fabrics to improve the strength and flexibility of adhesive bonded seams; (2) the effect of seam configuration on the strength of bonded seams and the comparison of bonded and sewn seam strengths; (3) the evaluation of different energy sources for stitchless joining; (4) a new NASA developed encapsulated adhesive that requires only pressure activation. The surface treatment of fabrics and the new encapsulated adhesive were considered particularly promising.

Surface modification of fabrics has improved flexibility and strength of adhesive bonded seams. A number of aerospace programs have investigated such surface modification. In particular, the Rock Island Arsenal has carried out an in-house program on stitchless joining by means of heat sealing. Not only have they found a beneficial surface modification for nylon fabric (treatment with dimethylsulfoxide prior to joining), but they have also investigated other process variables such as seam configuration and method of energy application.

The new encapsulated adhesive was developed by NCR under contract to NASA. It is pressure activated. This eliminates the need for heat. Degradation of fabric appearance and durability due to heat would not occur using this adhesive for stitchless joining. Since only pressure is required, machinery for forming the bond can be simplified. There should be no limitation on seam length such as is inherent in some of the present machinery, e.g. ultrasonic welders. A tape containing the encapsulated adhesive could be provided.

In the fall of 1970 the Stitchless Joining Committee of the Apparel Research Foundation met to consider these technologies. In particular they were impressed with the NCR encapsulated adhesive. In response to the work statement that had been circulated Dr. Radnovsky of the NASA Manned Spaceflight Center in Houston had recommended the use of a pressure activated, encapsulated adhesive system. It was Dr. Radnovsky's group in fact that had monitored the NCR contract. During

the NASA contract NCR had developed a formulation with a marked increase in adhesive strength. Dr. Radnovsky's concept was to take advantage of the increased strength by applying the adhesive in dots along a line, thereby duplicating the physical structure of a sewn seam. Dr. Radnovsky also felt that pressure activation offered the potential of simple machinery for carrying out stitchless joining using the adhesive system. These concepts were of particular interest to the Stitchless Joining Committee of the Apparel Research Foundation.

As the next step a meeting was held on January 19, 1971 with representatives from NASA and ARF. At this meeting the ARF representative, an Assistant R&D Manager, was acquainted with the problem and some discussion was held of the applicability of the adhesive system to stitchless joining.

At this point there were some key technical questions that needed to be answered. The strength of seams as a function of the size and spacing of the adhesive dots was unknown. Another concern was the appearance and physical characteristics of a seam using adhesive dots. There might exist modifications in the adhesive system which would be desirable for the stitchless joining application. The answers to these questions would determine those seams to which the system could be applied without substantial further development work on the adhesive. NCR agreed to propose a program to ARF which would obtain these answers.

Next several discussions were held between the NCR Assistant R&D Manager and representatives of the apparel industry. On March 1 and 3 he visited the plants of Arrow and Kessler, respectively. Kessler is a manufacturer of tailored men's clothing. On both occasions he was shown the complete manufacturing process from beginning to end. He became acquainted with those seams to which stitchless joining could be readily applied. He also became acquainted with some of the problems that will restrict application. For example, some seams in tailored clothing need to be sewn in order to make alterations possible.

On March 2 representatives of NCR and ARF and the writer met in New York to discuss the NCR proposal. At this meeting it was necessary to refocus the NCR approach along the specific lines discussed above. The proposal needed to concentrate on the two key points which distinguished the NASA developed technology from others. These were the use of an adhesive system of sufficient strength that it might be applied as a dotted line and the use of microencapsulation so that the adhesive system could be activated using pressure alone. After this meeting and the industry discussions, NCR prepared and submitted the proposal to ARF.

The initial proposal went beyond an initial determination of feasibility of the Radnovsky concept and put forth a rather complete program to develop an entire stitchless joining process. This included optimizing the formulation of the adhesive for specific fabrics, optimizing the properties of the capsules, evaluating techniques for applying the capsules to the fabrics, evaluating the methods for rupturing the capsules and curing the adhesive that could be integrated into automatic equipment, and finally evaluating the physical, mechanical and aesthetic

properties of the bonded fabric.

The Board of Directors of ARF considered this proposal at their meeting in Washington on April 21. The Board was quite enthusiastic about the above concept. They decided, however, to turn down the proposal, but in such a way as to leave the door open for some program between NCR and ARF. They felt that the industry should not spend a large sum on developing this specific concept without first comparing it to other approaches and obtaining more information as to its technical and economic feasibility.

On April 22 the writer met with the Executive Vice President of ARF to discuss this situation. We agreed that our immediate objective should be to seek alternative ways of ARF working with NCR. As the first steps toward this objective ARF wrote a letter to NCR to explain the position of the ARF Board. I then planned an informal visit to NCR while in Dayton on other business. The purpose of this visit was to determine better their goals and whether or not the research and development group was really the best group for ARF to work with.

On May 18, 1971 the writer visited the Assistant R&D Manager at the NCR laboratory in Dayton, Ohio. Shortly prior to this visit he had received a letter from ARF explaining the position of their board in turning down the NCR proposal. NCR felt strongly on two technical points. First, they believed that a specific adhesive system needed to be formulated for each major class of fabric. Second, they felt consideration of the equipment for applying the adhesive needed to go hand in hand with the adhesive development itself. Consideration of these factors are what led them to propose the complete development program to ARF.

These were valid technical points. The management in the apparel industry first had to be convinced, however, that the concept was a feasible one. ARF needed two pieces of fabric that had been put together using the dotted seam. NCR felt they could accomplish such a proof of feasibility with a much reduced effort. They prepared a revised proposal which ARF plans to submit to industry. The end result will be a demonstration of the feasibility of the concept which was proposed by Dr. Radnovsky.

During my discussion with NCR in Dayton a number of other points were brought out. The development laboratory there was primarily concerned with new industrial applications of microencapsulation. They were interested in the application of adhesives in the apparel industry. To invest their own money in the development of a stitchless joining process, however, would require much more extensive market research than they had currently undertaken. They would probably not be interested in the manufacture of machinery for application of the adhesive, but NCR does have the capability of developing and designing such machinery.

NCR would have been reluctant to submit samples of encapsulated adhesive for

evaluation in a stitchless joining process by any other laboratory. Their experience has been very poor regarding outside evaluations of encapsulated products. One problem has been a lack of familiarity with the product leading to improper use. Another problem in the case of stitchless joining is that for a realistic comparison the adhesive system needs to be designed for the application. This would require work on the part of NCR. It is partly this work, in fact, which was contained in the revised proposal.

This sequence of events is a good illustration of the type of third party effort which can be fruitful in technology transfer to small business. Let us assume that an industry problem has been defined and that aerospace technology relevant to that problem has been identified. Let us also assume that in order to apply the technology to the problem a new product must be supplied to the industry. The industry organization to which the technology has been transferred must in turn find and motivate a manufacturer for the new product. This was the state of affairs after the stitchless joining technology had been transferred to ARF. In addition, further application engineering was required in order to develop the new product.

There are two major problems which can arise in this situation that can impede technology transfer. One is inertia on the part of the industry organization and the potential new product manufacturer. In other words there is a tendency to take no action at all rather than to actively pursue the planning of a joint program. Since we are concerned with the case where a third party has transferred technology to the industry organization, the specific new product which must be developed is a new consideration for both the industry and the manufacturer. Since it is new the people who must become involved must do so at the expense of their current programs. This requires motivation. It must be clear to both the industry and the manufacturer as to how each is going to benefit from further action. A third party can contribute by making clear to each what these benefits really are and in structuring a program which is consistent with the constraints of both the industry and the manufacturer. The above study provides a case history where this was done.

A second problem which arose in the above study was a lack of understanding of the industry on the part of the manufacturer which had to develop the new product and a lack of understanding of the needs of the manufacturer by the industry. Each recognized this lack of understanding and took steps to remedy it. Several discussions were held between the representative of the manufacturer and representatives of the industry. There were plant visits. Even so there was misunderstanding as to what the industry really wanted in the way of an initial development program. On the other hand the industry had no comprehension as to what had to be done technically to prove the feasibility and then develop the new product. It was thus impossible for them to judge whether modifications in a proposed program were technically feasible. Technical intervention by a third party was useful in overcoming these barriers.

The nature of the role of a third party in stimulating the transfer of technology

from an industry organization to the industry itself would vary considerably from one case to the next. The two problems discussed above, however, are considered to be general. The function of the third party would tend to be the same as in the above illustration even though the specific activities to accomplish this function varied. A method for achieving such third party action in a number of industries is recommended in the final section of this report.

AUTOMATIC FABRIC GUIDANCE -- SEARCH FOR NASA TECHNOLOGY

A new problem was selected for analysis and subsequent transfer of technology to ARF. At the request of ARF this effort was directed at automatic fabric guidance during sewing. ARF had identified the sewing operation as the best opportunity for improving the manufacturing process. In particular the industry needed a method for automatically guiding at different rates through a sewing machine two pieces of fabric with their edges aligned. No automatic machinery had yet appeared on the market for seams of this type. Different feed rates are required when the two pieces of fabric have nonmatching contours. Many seams of this sort are necessary in order to build a three-dimensional garment from two-dimensional pieces of cloth.

The problem was analyzed using technical reports from ARF and prior interviews with representatives from the industry. Many sewing operations require such skill that the operators must have months of training before they become efficient. The operator in general performs three tasks. She removes the two pieces that are to be joined from stacks. She then aligns the two pieces and guides them through the sewing machine. A need of the last few years has been the automation of the operator's tasks. Machinery is available now in which guidance is done automatically for some seams. With such automatic machines one operator can now feed pieces to two or more machines whereas before she was limited to just one machine. The rate of stitching in the automatic machine has remained about the same but production rate per operator has more than doubled. Examples of machines with automatic guidance are button-hole stitchers and automatic pocket stitching machines.

There are two typical methods in use today for achieving automatic guidance. The most common approach is to use templates. The operator aligns the two pieces that are to be sewn together, a template is put in place, and the machine automatically sews a seam following the outline of the template. A second approach is to use optical sensing of the fabric edge and thereby control the orientation of the fabric as it is pulled through the sewing machine head.

When the two pieces being sewn together do not have edges with matching contours, the above automatic guidance methods are not applicable. At present the operator must grasp each piece of fabric and guide them under the sewing head at different relative rates. Thus not only must she align the edges of the pieces as the seam is being sewn but she must individually control the feed rates of each piece. This requires an experienced operator plus a learning period for each new seam. There is a priority need for automatic guidance applicable to this type of seam.

The guidance system must control the relative alignment of the edges of the two

pieces of fabric and must control the relative feed rates to the sewing machine. If the system were analogous to the present human control there would be some mechanical device individually grasping each piece of fabric behind the sewing head. There would be a sensor to detect whether or not the edges of the fabric pieces were aligned. In case of misalignment the mechanical grippers would move relative to one another to bring the edges into alignment. There would also be sensors to determine the rate at which each fabric piece was passing under the sewing head. The effect of each mechanical gripper would be to place the fabric between the sewing head and the gripper under tension. Feed rate would be controlled by controlling the amount of this tension. The feed rates would be adjusted so that even though the edges were of different lengths, neither fabric piece overlapped the other upon completion of the seam.

A problem statement was prepared and used as the basis of a literature search. It and the results of a brief manual search were forwarded to KASC. All of the citations identified in the KASC strategy were then screened by the writer and documents containing potentially relevant technology were ordered. Based on the results of this literature search an expanded problem statement was prepared and circulated to the NASA Field Centers. This problem statement is in Appendix A. It contains illustrations of the potentially relevant technology that were taken from the literature search:

Relevant technology was identified in essentially three different areas. These were mechanical devices for controlling or sensing fabric tension, optical measurement of fabric surface velocity, and manual control technology. In each of these areas a further manual search was carried out based on the documents received from the KASC search. Additional NASA-generated technology relevant to the problem was identified.

In an automatic guidance system there must be a mechanism for controlling the relative rate of movement of two pieces of fabric as they are fed intermittently to a sewing head. Technology related to the real time control of tension and forces would thus be relevant. Such a mechanism was found in NASA Tech Brief 66-10107. The latter discloses a mechanism for continuously measuring the tensile load on a cable without disturbing the operation of that cable. The cable moves through the mechanism, and the tensile force is measured independently of the velocity or direction of cable movement.

Second, there must be a method of sensing the rate at which the fabric is moving. Controlling the rate of movement places the fabric under tension. The amount of this tension, however, depends not only on the specific fabric but also on the angle between the weave and the direction of feed under the sewing head. The fabric may also distort under tension. Laser velocimetry offers a non-contact method of measuring surface velocity. In the literature search it was found that this and closely related methods using lasers have been applied by NASA to the measurement of gas velocities. NASA has refined the methods and developed instrumentation. Most of the NASA work has involved use of the Doppler

principle in measuring velocity. If a laser beam is scattered by a moving particle there is a shift in the frequency of the light that is related to the velocity of the particle. With a suitable optical arrangement the scattered and original laser beams can be caused to interfere, producing moving fringes that can be detected and that are related to the velocity. A potential advantage of this technique applied to measuring the fabric surface is that it would tend to measure the velocity of individual threads and be independent of surface distortion.

The sewing of two fabric pieces with non-matching edges is presently a manual control problem. Learning time for the operator is long, at least several weeks. Feedback to the operator during sewing comes purely from observing the end result after each seam is completed. The use of a display could provide more immediate feedback and decrease the learning time. NASA has done extensive work on manual control and some of this has involved the investigation of the effect of various types of display on the control process. For example, one type of display that may be applicable is the predictive display. In this a parameter is calculated and displayed which reflects a future result based on the present system status. In guiding fabric pieces with non-matching contours under the sewing head the significant future result is the overlap. The relative rates of the two pieces of fabric must be controlled to minimize this overlap. At present the operator must complete the seam before she knows how well she is doing. A predictive display would allow the operator to take corrective action during the sewing of the seam.

A report was prepared on the above NASA technology to the Apparel Research Foundation. A copy of this report is in Appendix B. After their review and comments it was concluded that optical methods of measuring fabric velocity would be the most significant contribution to solving the guidance problem.

In the report recommendations were made to ARF for follow-up in each of the areas of technology. The mechanical devices are such that they could be made in an apparel manufacturer's shop. They could also provide the manufacturer with an immediate means for controlling the movement of fabric under the sewing head. For this reason it was recommended that the mechanisms be covered by announcements in the series, "From Space Research to You". The optical methods of measuring velocity were more complex. In this case it was recommended that ARF representatives discuss the problem with NASA personnel familiar with the technique. Proposals for application engineering could then be solicited from suitable manufacturers. Finally it was recommended that ARF sponsor a meeting between representatives of the apparel manufacturers, the machinery manufacturers, and NASA personnel familiar with manual control systems. In such a meeting the industry would benefit from two-way communication. Present would be those familiar with the specific problem in the apparel industry and those from NASA familiar with advanced techniques for solving a general class of similar problems. The application of these advanced techniques in a manner consistent with the peculiarities of apparel manufacturing could be considered.

ANNOUNCEMENTS OF NEW TECHNOLOGY

In the previous project some technology had been identified which could be applied to apparel industry problems without application engineering. When NASA reports were sent to selected firms in the industry, however, a negative response was obtained as to their utility. For this reason, it was decided with ARF to try a new approach as an experiment in the present project. A series of announcements would be prepared by the writer and these would be specially written for the apparel industry. Both NASA Tech Briefs and technical reports would be used as source material. The announcements would then be edited by ARF and distributed to their membership. This has been done and a survey of the membership has indicated a highly favorable response to the series.

In the announcements the technology is described in terms of its role within the apparel manufacturing plant. The benefits of using the technology are pointed out. The original aerospace application of the technology is only briefly mentioned or not discussed. Also an effort was made to write in a style consistent with that used in apparel industry trade journals. The Apparel Research Foundation had a consultant, Mr. Abe Weinkle, review and edit the announcements from the point of view of the apparel manufacturer. Mr. Weinkle worked for years at Phillips Van Heusen, is well respected as an expert in the industry, and has a good technical appreciation of what the industry can use. He reviewed the announcements and selected those most relevant to the industry needs. Only the latter were then distributed by ARF. Copies of all the announcements submitted to ARF are in Appendix C. These were distributed under the cover sheet shown as Figure 1 with the title, "From Space Research to You". The reaction of the ARF staff to these announcements was quite favorable. They felt that they would be far more meaningful to those in the apparel industry than the original source material. They felt that it was necessary in most cases to show how the new technology was relevant to some specific apparel manufacturing problem.

To determine the reaction of the membership to the series, "From Space Research to You", ARF conducted a survey after two sets of announcements had been distributed. The questionnaire used in this survey is shown in Table 1. The purpose was to determine whether the ARF membership felt the series should continue as an ARF service to their members and also to determine if any of the information was used by the member firms. In general the survey indicated a high degree of interest on the part of industry in this service. The results are considered particularly promising in that they indicate that the same type of service might be supplied to other industries as a transfer mechanism.

The statistics of the survey results are shown in Table 2. In Table 3 are given the comments that were received. The first conclusion that can be drawn from the statistics is that there was predominant acceptance of the service. Of the

respondents, 67% said that they may use some of the reported technology and 85% said that they wish the service continued. Two of the respondents reported using some of the technology now. These results indicated a receptive attitude toward new technology. This is important for transfers to take place as a result of announcements in the series. This attitude was confirmed by the comments given in Table 3.

The next step in evaluating the announcements was interviewing some of the recipients by telephone. Those firms were contacted that reported they were or could use the reported technology. A list of the people interviewed is given in Table 4. In each case the person confirmed that the announcements were of value to their firm. In those three cases indicated the firm is evaluating some items of technology in their engineering or research department. Insufficient time had elapsed between receipt of the announcements and the survey, however, for actual use of the technology by the firms. Each person interviewed was optimistic that eventually their firm would use technology received in the series provided the series continued.

It was concluded that announcements prepared as above provide a new tool in technology transfer to industry. A key factor in the positive attitude of the industry toward them was the manner in which they were prepared. That is, a manager of the apparel firm was instructed as to how he could solve one of his problems. Review and editing by an industry expert is considered a significant part of the process. Recommendations are given in the next section for expanding the application of this tool to other industries.

RECOMMENDATIONS

The response of the members of the Apparel Research Foundation to the announcement series, "From Space Research to You", has been quite favorable. Those members that have returned the survey questionnaire have strongly recommended that ARF continue the service. This matter has been discussed with Julian Huffer of ARF and he feels that they can pay for most of the cost of preparing these announcements. In other words, now that the industry has been exposed on an experimental basis to what can be done they would be willing to support the service through ARF. This attitude has developed, however, only as a result of specially preparing the announcements for the apparel industry. When NASA reports containing similar technology were circulated to firms in the industry, the response was negative, as has been discussed above.

It is concluded that an announcement series specially prepared for a particular industry is a valuable tool to achieve technology transfer to that industry. It is thus recommended that trial programs similar to that with ARF be established with other industries. Once the value of the announcement series in each case is demonstrated it is expected that the industry would then cover the costs themselves. It would be necessary, however, to first demonstrate the value of the announcements to the industry, since they would be unfamiliar with articles of this sort. These are articles in which the managers would be given explicit guidelines as to how they could solve one of their problems. The technology used in the solution, however, would be aerospace technology developed for a completely different purpose.

Such a trial program would involve the preparation of sample announcements for distribution to the industry through an industry organization. Only NASA generated technology would be covered in the announcements. Feedback would be obtained from a survey of the recipients. A proposal would then be provided to the industry for continuing the service with their offsetting the costs. From the experience with the apparel industry it is considered important that the announcements be tailored to the specific industry. This would require an initial investigation of industry problems through discussions with the industry organization and at least one plant visit. It would also be useful to locate an industry consultant who could review and edit the announcements. After this preparatory work, NASA generated technology would be screened for potential relevance to the specific industry. The manner in which the industry would use the technology would be envisioned. Announcements would then be written in a style familiar to industry management.

The second successful transfer mechanism established with ARF is the selection of a specific problem and the exhaustive search for technology and NASA generated ideas relative to it. This is the application team approach. In working with an industry organization follow-up activities to initiate application engineering

also are a key factor. As a result of success on the present project it is recommended that a continuing program be established by NASA and expanded to other industries. Most of the costs would be borne by the industry itself.

A specific approach for accomplishing this has been discussed with ARF. This would involve their submitting a proposal to their members for funding a two-phase project aimed at solving a specific industry problem. In the first phase, a problem statement would be prepared and then NASA generated technology would be sought relevant to the problem. In the second phase application engineering would be carried out to find a solution to the problem using the NASA technology identified in the first phase. ARF feels that a key point is for the initial proposal to industry to provide for this application engineering. Although industry would cover most of the cost of the project, it is recommended that NASA cover enough of the cost to get focus on NASA generated technology and to guarantee documented feedback. The mechanism for the latter would be built into the program. It is recommended that this approach be initiated on a specific project with ARF and then extended to other industries on an experimental basis.

TABLE 1
SURVEY QUESTIONNAIRE

The National Aeronautics and Space Administration has asked for an evaluation of this type of industry assistance and we need your help. Based on the two issues you have now received, please complete the form below and return it to ARF's office at your earliest convenience, but no later than July 19, 1971.

TO: The Apparel Research Foundation, Inc.
1120 Connecticut Avenue, Suite 823
Washington, D. C. 20036

1. The bulletin "From Space Research To You" is:
a) interesting _____ b) useful _____ c) of no value _____
2. We a) can use _____ b) may use _____ c) are using _____ the information supplied.
3. We favor a) continuing its publication _____
b) discontinuing its publication _____
4. Comments:

Name: _____

Company: _____

TABLE 2

"FROM SPACE RESEARCH TO YOU"

SURVEY OF RECIPIENTS

Responses --

Total Responses: 48

Value of the Announcements --

Interesting: 32	Useful: 18	No Value: 2
-----------------	------------	-------------

Use of the Technology --

Can Use: 7	May Use: 32	Are Using: 2
------------	-------------	--------------

Recommendation --

Continue Service: 41	Discontinue Service: 2
----------------------	------------------------

TABLE 3
"FROM SPACE RESEARCH TO YOU"
COMMENTS FROM RECIPIENTS

Please continue and expand to more pages.

We are currently investigating some of the possibilities from these notices.

Most topics covered to date do not relate to our operation.

Very helpful from our point of view, primarily research and engineering and product development.

Are using the information supplied.

These publications contribute to cross-fertilization across disciplinary boundaries. We believe this to be highly valuable.

It may take many issues before an immediate problem is answered, however, we should continue.

If continued some items may be of interest.

Informative-selectively.

We are bound to "hit a winner" sooner or later. Gives the little man with no R/D funds a leg up against big brother.

Do not think this type of service is what we should be promoting in ARF.

For our company no value.

Continue publication if cost to ARF other than printing and mailing is small. No immediate use seen for items in this particular issue.

Are using, this is an excellent service!

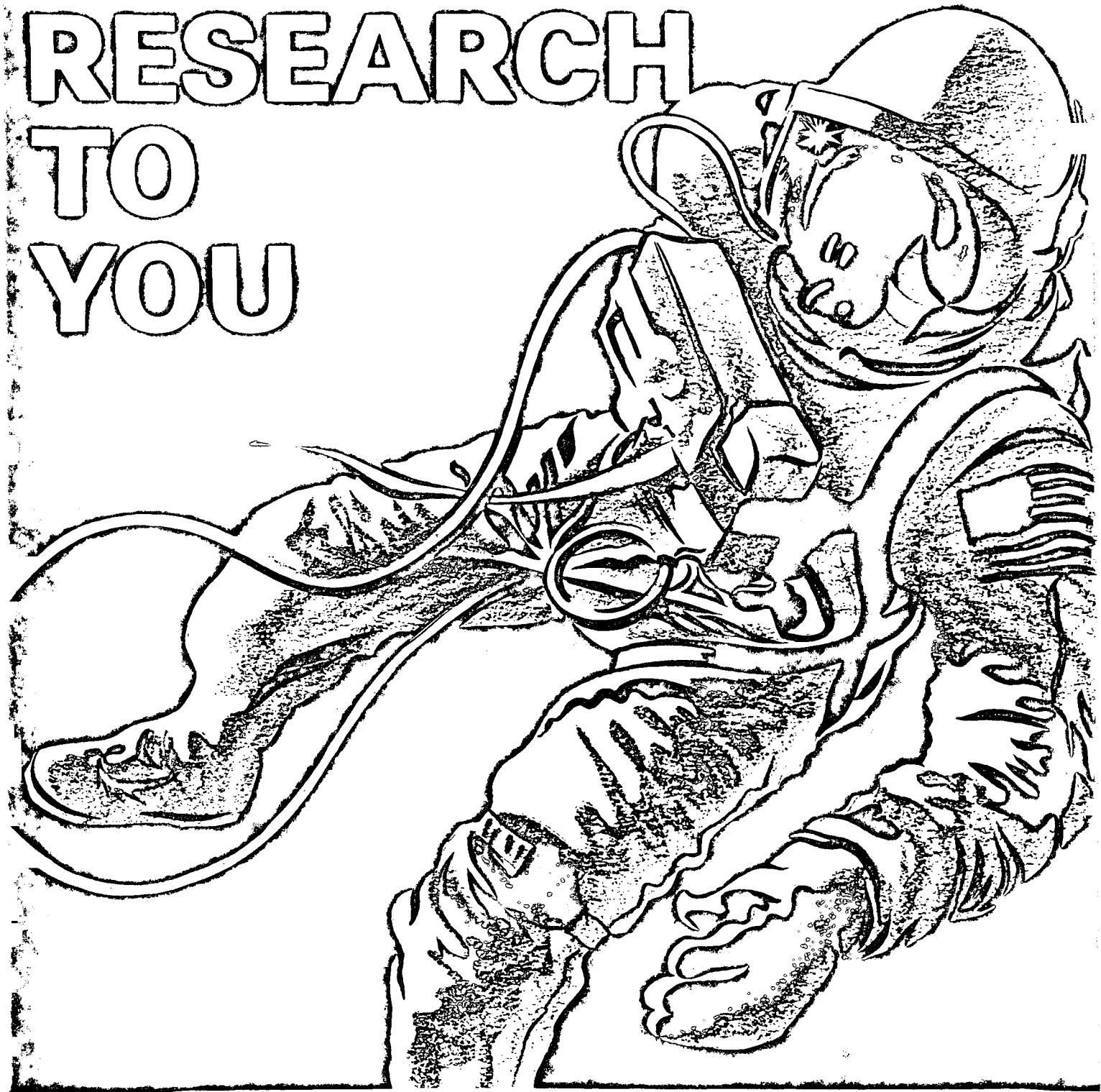
An interesting presentation, but of little use to us at this point.

TABLE 4

INTERVIEWS REGARDING ANNOUNCEMENTS

<u>Person Interviewed</u>	<u>Value of Service</u>	<u>Use of Specific Technology</u>
Donald B. White Compo Industries Inc. Waltham, Mass.	Considers the service excellent	The knee-operated switch and self-lubricating gear are being investigated by engineering.
Elwin J. Buchanan Greensboro Mfg., Inc. Greensboro, N. C.	Confirmed value	Nothing to date
Tom Loschiavo Rosenau Bros. Inc. Philadelphia, Pa.	Expect to find ideas for plant equipment	Nothing to date
Ralph Burgdorf Angelica Corp. St. Louis, Mo.	Mechanical items are of the greatest value to them	R&D is investigating the knee-operated switch.
Barry W. Stuart Southern Machinery Co. Greer, S. C.	Of value to research in pointing out new materials	Some items are being evaluated in engineering.
William C. Giesker Scovill Mfg. Co. Waterbury, Conn.	Confirmed value, particularly of new mechanical items.	Engineering is evaluating the apparel design for reduced flammability.
John Milholland Kellwood Company St. Louis, Mo.	Feel that they may identify something new from the announcements	Nothing to date

FROM SPACE RESEARCH TO YOU



THE APPAREL RESEARCH FOUNDATION, INC.
IN COOPERATION WITH
THE NATIONAL AERONAUTICS & SPACE ADMINISTRATION

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APPENDIX A

PROBLEM STATEMENT -- AUTOMATIC FABRIC GUIDANCE

Automatic Fabric Guidance (SB-2)

What is Needed

A method is needed for automatically guiding at different rates through a sewing machine two pieces of fabric with their edges aligned.

Background

Solving the problem discussed in this statement would contribute to improving the economic health of the domestic apparel industry and better enable them to meet competition from imports. The industry is dominated by small firms. Of 24,979 establishments in 1967 only 264 had 500 or more employees. The average number of employees per firm is about 55. Of the total employment of 1.4 million there are 1.2 million who work in firms with fewer than 500 employees. Due to the small size of the average company there has been a low level of R&D expenditures. Nevertheless, technological improvements in manufacturing methods could be very significant to the industry. The industry has a high labor content and during the past decade has experienced increasing pressure from imports. The latter have risen from \$283 million in 1960 to \$1179 million in 1969. Improved productivity is required to meet foreign competition. This could be achieved through automating manufacturing methods, and the industry has sponsored research with this objective through the Apparel Research Foundation.

The latter organization has identified the sewing operation as a particular opportunity for improvement of the manufacturing process. Many sewing operations require such skill that the operators must have months of training before they become efficient. The operator in general performs three tasks. She removes the two pieces that are to be joined from stacks. She then aligns the two pieces and guides them through the sewing machine. A need of the last few years has been the automation of the operator's tasks. Machinery is available now in which guidance is done automatically for some seams. With such automatic machines one operator can now feed pieces to two or more machines whereas before she was limited to just one machine. The rate of stitching in the automatic machine has remained about the same but production rate per operator has more than doubled. Examples of machines with automatic guidance are button-hole stitchers, and automatic pocket stitching machines.

There are two typical methods in use today for achieving automatic guidance. The most common approach is to use templates. The operator aligns the two pieces that are to be sewn together, a template is put in place, and the machine automatically sews a seam following the outline of the template. A second approach is to use optical sensing of the fabric edge and thereby control the orientation of the fabric as it is pulled through the sewing machine

head. There are many seams in a garment in which the two pieces being sewn together do not have edges with matching contours. This is necessary in order to construct a three-dimensional garment from two-dimensional pieces of fabric. The above automatic guidance methods are not applicable to such seams. At present the operator must grasp each piece of fabric and guide them under the sewing head at different relative rates. Thus not only must she align the edges of the pieces as the seam is being sewn but she must individually control the feed rates of each piece. This requires an experienced operator plus a learning period for each new seam. There is a priority need for automatic guidance applicable to this type of seam.

The guidance system must control the relative alignment of the edges of the two pieces of fabric and must control the relative feed rates to the sewing machine. If the system were analogous to the present human control there would be some mechanical device individually grasping each piece of fabric behind the sewing head. There would be a sensor to detect whether or not the edges of the fabric pieces were aligned. In case of misalignment the mechanical grippers would move relative to one another to bring the edges into alignment. There would also be sensors to determine the rate at which each fabric piece was passing under the sewing head. The effect of each mechanical gripper would be to place the fabric between the sewing head and the gripper under tension. Feed rate would be controlled by controlling the amount of this tension. The feed rates would be adjusted so that even though the edges were of different lengths, neither fabric piece overlapped the other upon completion of the seam.

Constraints and Specifications

There are some unique aspects associated with joining fabrics that must be taken into consideration.

Flagging of the material must be prevented for reliable stitching operations. Thus fabric is held in tension during needle penetration and removal.

Cutting tolerances are loose, 1/8" - 1/4", making the presence of an edge sensor necessary in automatic equipment. Even the shape of the part may vary from piece to piece as a result of the loose tolerance.

If a seam is to look straight deviations from linearity must not exceed 0.01".

The fabric should be stationary during penetration of the needle. This requires an intermittent feeding mechanism. Sewing speeds are 6,000 stitches per minute with such feeds.

The direction of feed generally must be controlled within 20° and depends on the type of stitch.

Characteristics of Relevant Technology

There are three areas in which innovation is required. First, there must be a method for manipulating the fabric during automatic guidance. Thus methods

of gripping, manipulating, and handling of limp material would be relevant. Second, there must be a method of sensing the rate at which the fabric is moving. For fabrics which distort under tension the number of stitches which pass by the sensor per unit time must be measured. Unique non-contact methods of sensing surface speed as well as mechanical sensors would be relevant. For example, laser velocimetry¹ has potential applicability. Surface velocity is measured by observing the reflections from a laser beam directed on the surface. The reflections form a diffraction field which moves in space as the surface moves. The movement of the diffraction field can be detected as a frequency spectrum using an optical grating. Other unique methods of measuring surface velocity need to be identified.

Third, there must be a mechanism for controlling the relative rate of movement of two pieces of fabric as they are fed intermittently to a sewing head. Technology related to the real time control of tension and forces would be relevant. The type of technology that would be useful is illustrated by NASA Tech Brief 66-10107. The latter discloses a mechanism for continuously measuring the tensile load on a cable without disturbing the operation of that cable. The cable moves through the mechanism, and the tensile force is measured independently of the velocity or direction of cable movement.

References

1. Philip C. Stass, Jr., "Laser Velocimetry", M.S. Thesis, Air Force Institute of Technology, August 1964, N65-17373.

For Further Information

If you need more details about this problem, please contact:

William H. Clingman
W. H. Clingman & Company
1600 LTV Tower
Dallas, Texas 75201

Telephone: (214) 747-7073

APPENDIX B

REPORT TO THE APPAREL RESEARCH FOUNDATION

NASA Technology Relevant to Automatic Fabric Guidance

Introduction

One of the principal objectives within the apparel manufacturing industry is to increase output per worker. Automation of the sewing operation must play a key role in this. In response to this general need some automatic equipment is now beginning to appear on the market. Edge sensors guide single pieces of fabric through the sewing head. Templates are used in automatic pocket stitchers. One of the areas where automation is required is in the sewing of contour seams. These are where the edges of the fabric pieces being joined do not match. It is in this area that progress has not been made.

Such seams are always required in making a three dimensional garment. Sewing such seams has a long learning time for the operator. She must feed the two pieces under the sewing head at different rates. The operator does not know, however, whether or not the relative rates she is using are correct until the seam is completed. This contributes to the learning time.

Three areas of technology have been identified which can contribute to the solution of this problem. This technology was originally developed as a part of the space program. These three areas are: mechanical devices for measurement and/or control of fabric movement under the sewing head; optical techniques for measuring fabric velocity; and displays that aid in manual control.

The mechanical devices include a tape which is attached to the fabric and is coded so that when it is passed under a reader the velocity is measured. Also included is a mechanism through which the fabric can pass, and the mechanism gives a continuous measurement of tension. Tension is related to the rate at which the fabric passes under the sewing head.

The optical method of measuring fabric velocity is sensitive to the number of threads per second passing under the sewing head. This is true even when the fabric is under tension or stretched, thereby increasing the distance between the threads. The method involves the change in frequency of a light beam that is reflected or diffracted from the thread as a result of its motion. By being sensitive to threads per second, positive control can be achieved over the amount of fabric between each stitch.

A third approach is to provide the operator with a display that assists her in the manual control of the sewing process. One of the basic problems in manual control is that the operator does not know the result of her actions until the seam is complete. NASA has done extensive work on predictive displays. In these the future result of current control actions is displayed.

Some means of sensing fabric tension or velocity would be necessary as an input to the predictive display. Control, however, would still be manual. It has been shown in tests on human subjects in other manual control problems that such predictive displays can improve performance and decrease learning time. The latter is an important factor because of the high turnover rate in the apparel industry. After a discussion of the problem background, each of these technology areas is discussed in more detail. This report is then concluded with a set of recommendations for exploiting the NASA technology described.

Background

The apparel industry has a high labor content and during the past decade has experienced increasing pressure from imports. Improved productivity is required to meet foreign competition. This could be achieved through automating manufacturing methods, and the industry has sponsored research with this objective through the Apparel Research Foundation. The sewing operation provides a particular opportunity for improvement. Many sewing operations require such skill that the operators must have months of training before they become efficient. The operator in general performs three tasks. She removes the two pieces that are to be joined from stacks. She then aligns the two pieces and guides them through the sewing machine. A need of the last few years has been the automation of the operator's tasks. Machinery is available now in which guidance is done automatically for some seams. With such automatic machines one operator can now feed pieces to two or more machines whereas before she was limited to just one machine. The rate of stitching in the automatic machine has remained about the same but production rate per operator has more than doubled. Examples of machines with automatic guidance are button-hole stitchers, and automatic pocket stitching machines.

There are two typical methods in use today for achieving automatic guidance. The most common approach is to use templates. The operator aligns the two pieces that are to be sewn together, a template is put in place, and the machine automatically sews a seam following the outline of the template. A second approach is to use optical sensing of the fabric edge and thereby control the orientation of the fabric as it is pulled through the sewing machine head. Many seams, however, require two pieces of fabric to be fed at different rates under the sewing head. The above two methods do not by themselves solve this latter problem.

Such seams are necessary to produce a three dimensional garment from two dimensional pieces of fabric. Examples are shirt collars and cuffs. After completing a seam the operator must observe which piece of fabric overlaps the other at the end. The operator must then adjust the relative rate at which she is feeding the pieces when she sews the next seam. To make this adjustment requires her remembering the relative tension that she was applying to the fabric pieces. This tension is applied between her fingers and the sewing head. The operator has no immediate feedback as to whether the relative feed rates she is using are correct. It may be difficult to reproduce the same feed rates from one seam to the next. Thus there will likely be an error in adjusting the relative feed rates. This contributes to the long learning time for this particular type of seam.

Technology which can contribute to solving this problem falls into two general classes. First would be a completely automatic guidance system. Second would be an improved system with the operator still a part of the control process. A completely automatic system would consist essentially of four basic parts. First is a mechanism for gripping each piece of fabric from behind the sewing

head. This mechanism or gripper must control both the position of the fabric and the rate at which it moves under the sewing head. The latter is controlled by the gripper applying tension to the fabric, restraining its movement. There is a mechanism described below which could be used for measuring or applying tension to the fabric. Second is a means for sensing the position of the fabric edges so that they can be aligned. This type of sensing is already being done in commercial equipment. Both fluidic and photoelectric sensors can be applied. Third is a means of sensing the rate of fabric movement of each fabric piece under the sewing head. It is in this area that the NASA technology described below could make a primary contribution. Due to the flexibility and stretching characteristics of the fabric this problem is one that is somewhat unique to the industry. Fourth is the control unit which takes the information from the velocity and position sensors and operates the grippers. Electronic technology for this type of feedback controller has long been available.

The second class of technology would be applicable to a control system still involving the human operator. If the operator is still active in the control process, it is likely that she would continue to do part of the same tasks that she is currently doing. That part which she can do readily is to align the fabric edges and apply tension to the pieces. What is difficult is for the operator to know how much tension to apply. This can be solved with display technology and particularly relevant NASA contributions in this area are discussed below.

Mechanisms

A mechanism is illustrated in Figure 1 which would provide for the continuous measurement of tension of fabric passing through it. As shown it is designed for a cable but could be modified for a piece of cloth. The mechanism consists of a set of takeoff pulleys mounted on a pivoted frame that is linked to a strain gage which measures the frame displacement as a function of the static or dynamic tensile load on the cable. The pivoting frame has a small pulley mounted at its lower end, and a larger pulley at its upper end. This frame is mounted on a support containing a strain gage. The entire assembly is mounted over the takeup drum of a cable turn-control motor. The pulleys are arranged relative to the drum so that the cable makes a fixed angle at the points of incidence to and departure from the small pulley. The load on the small pulley will therefore be proportional to the load on the cable. An increasing load on the cable transmitted through the small pulley causes the frame to swing about the pivot axis and deflect the strain gage tongue downward in proportion to the cable load. The resulting output from the strain gage can be continuously monitored to give direct readings of the cable load. The two pulleys on the pivoting frame are free to translate on their axes of rotation in order to allow proper positioning of the cable as it traverses the takeup drum during winding or unwinding.

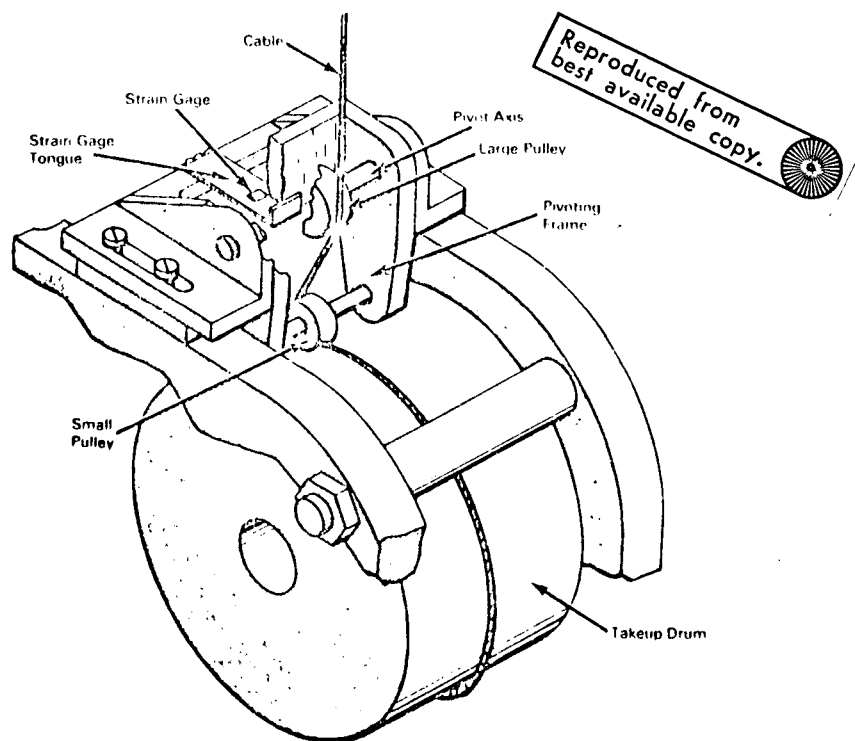
As a possible modification, a third pulley might be added to the two-pulley assembly. As the takeoff angle is a critical factor in calibrating the mechanism, the third pulley would be made adjustable in accordance with the anticipated load it is to carry. Under heavy load, the added pulley would be set approximately in the plane of the other pulleys, so that only a small component of the main load is applied to the strain gage. Under light loads, the third pulley would be set nearly perpendicular to the other two pulleys, in order to maximize the load on the strain gage.

The advantage of this mechanism is that it would allow for the measurement of fabric tension while the fabric is moving. Since it is desirable that the fabric not be moving when it is pierced by the needle, stitching is an intermittent process. It is the tension during the movement of the fabric that is significant in control. Measurement of this tension could provide an indirect measure of fabric velocity. The mechanism could thus be used as the velocity sensor described in the previous section. With slight changes the mechanism could also be used to apply a predetermined amount of tension on the fabric. In this case the mechanism would be a part of the fabric control assembly.

Further information on this invention can be obtained from the Technology Utilization Officer, Manned Spacecraft Center, Houston, Texas 77001. Inquiries should contain the reference, B66-10107.

A second mechanical approach to velocity measurement is to print or attach coded markings along the edges of the fabric pieces being joined. NASA has

FIGURE 1
Mechanism Continuously Measures Static and Dynamic Cable Loads



used this approach in measuring the movement of flexible materials. In that case conventional 1/2-inch magnetic recording tape was perforated along its longitudinal axis with two series of 1/4-inch diameter timing holes. The first series consisted of holes spaced on one-inch centers. This series was interrupted every 12 inches by the second series consisting of three-hole groups on 1/2-inch centers. The measurement was made by allowing the tape to pass between a light source and a photoelectric sensor. One end of the tape was attached to the flexible specimen whose velocity was to be measured. The other was held in a loose coil in a bin adjacent to the sensing device. The measurement was made by allowing the tape to be freely paid out and passed between a light source and a photoelectric sensor.

In applying this technique alternatives are to stamp the code onto the fabric or to pin the entire tape to the fabric. Further information on the NASA use of the technique can be obtained from the Technology Utilization Officer, Goddard Space Flight Center, Greenbelt, Md. 20771. Inquiries should contain the reference, B63-10512.

Optical Measurement of Velocity

In optical measurement a laser beam is reflected from the fabric surface or is passed through the fabric being diffracted by the fibers. The light is reflected or diffracted by the individual threads. When the thread is moving in a direction perpendicular to the light beam there is a Doppler frequency shift. At ordinary velocities this frequency shift is very small. This is the purpose of using the laser beam as the light source. Because the laser beam is monochromatic an interference pattern can be established between the original and the reflected or diffracted beam. The beat frequency of the interference pattern corresponds to the velocity of the thread. A detector can be set up for observing the interference pattern and thus measuring the thread velocity.

A photocell can detect the interference fringes. Electronic circuits attached to the photocell can determine the rate at which the fringes appear and convert this into the desired fabric velocity. NASA has applied this method to the measurement of velocity of particles suspended in moving gas streams. Particle velocity is used in turn to determine gas velocity. Most of the work has been carried out at the Marshall Space Flight Center.

Instrumentation for the method was developed by Raytheon under contract to the Marshall Space Flight Center. This is covered in the report NASA-CR-1100 and U. S. Patent 3,532,427.

Displays

As discussed above, when the human operator stays in the control loop the primary requirement is to provide the operator with information on the result of her actions. NASA has done considerable work on displays for this purpose in manual control systems. Much of this work has involved tests with human subjects to compare one type of display with another. From these tests it can be concluded that a visual display would be best. Alignment of a moving line with a fixed line would indicate proper control. The display could be realized by several techniques. One is a cathode ray tube. The fixed line would be drawn on the face and the moving line would be produced by the electron beam. A second and less expensive approach would be to use a simple galvanometer. The needle of the galvanometer would correspond to the moving line and the fixed line could be drawn on the face of the galvanometer.

There has been considerable study of predictive displays. These include an electronic circuit that computes the end result of the process. In our case this would be the extent of overlap between the two pieces of fabric. In computing this end result an extrapolation is made of the present situation. Both the current relative fabric velocities and the rate of change of these velocities are taken into account. The distance between the fixed and moving line on the display would then correspond to the predicted overlap at the end of the seam.

The operator could thus immediately correct the rates at which she is feeding the two fabric pieces. When the fixed and moving lines are superimposed, then the predicted overlap is zero, which is the operator's objective. This type of display could substantially decrease learning time.

Further information on the predictive display is available in NASA-CR-1274, "A Fundamental Study of Predictive Display Systems" by John DeShon Warner.

Recommendations

The mechanical devices discussed above are each of simple enough construction that they could be produced in a manufacturer's shop. They could thus provide the manufacturer with an immediate measure of the rate of movement of fabric under the sewing head. They could form the basis of a simple visual display for the operator. These mechanical devices might also be incorporated into new equipment by machinery manufacturers. Because they could be constructed in an average shop these mechanisms would be suitable material for an announcement in the series, "From Space Research to You". It is recommended that they be disseminated using this media.

To further exploit the developments in optical methods of velocity measurement it is recommended that ARF representatives discuss this area with NASA personnel associated with the developments. In particular the minimum requirement for instrumentation could be determined, and the ARF representative could benefit from the practical experience of the NASA personnel in applying the technique.

To exploit the work that NASA has done in manual control it is recommended that ARF sponsor a meeting between representatives of the apparel manufacturers, the machinery manufacturers, and NASA. The latter would be those experienced in manual control systems. In such a meeting the industry would benefit from two-way communication. Present would be those familiar with the specific problem in the apparel industry and those from NASA familiar with advanced techniques for solving a general class of similar problems. The application of these advanced techniques in a manner consistent with the peculiarities of apparel manufacturing could be considered. The meeting could also serve to establish a dialogue between the apparel manufacturers and the machinery manufacturers that could prove useful in setting up a subsequent development program. This type of meeting is recommended at this point in time as an experiment.

APPENDIX C

ANNOUNCEMENTS IN THE SERIES, "FROM SPACE RESEARCH TO YOU"

FROM SPACE AGE RESEARCH

A new hand tool for cutting and sealing fusible cloth has been developed in the space program. The big advantage of the tool over shears is that there is no raveling at the edge of the cut. The tool is simple to make.

The tool has three main parts. The handle is designed for easy gripping. At the end of the handle is a ceramic wheel. An electric heating wire is mounted in a criss-cross pattern around the rim of the wheel. It is actually this wire which cuts the fabric by fusing it. Where the wheel is mounted to the handle there are special electrical connections which allow the wheel to rotate. A cord runs from the handle of the cutter to a special electrical power supply.

The cutter is gripped at the tool handle and the wheel is guided along the cut line. The heated wires actually cut the fabric and seal it to prevent raveling.

The tool should be easy to build. Drawings for the tool and a circuit diagram for the power supply are available. To obtain these order document N69-21854 (NASA-CASE-SMF-9386) from the National Technical Information Service, Springfield, Virginia 22151. Price is \$3.00.

For those interested in manufacturing the tool as a product, a royalty free license is available to United States firms from NASA. For further information contact the Assistant General Counsel for Patent Matters, NASA, Washington, D. C. 20546.

Technical questions may be directed to:

Technology Utilization Officer
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135
Reference: B70-10670

FROM SPACE AGE RESEARCH

Anyone who wishes to expand their plant and uses permanent press fabrics should investigate a new heat treating technique that has been developed at the NASA Lewis Research Center. High velocity air jets impinge upon the material to be heated. It is expected that properly designed jets could increase the rate of heating a garment by an order of magnitude. Oven size for a given production rate could be decreased. It might be possible to increase the capacity of an already existing oven by adding such jets at the front.

The design of the jet is critical to achieve this improvement in heating rate. NASA has sponsored a study to obtain the engineering data necessary for this design. The shape of the nozzle, the distance of the nozzle from the garment, and the air velocity must all be considered. Studies of these design variables have been made for NASA by P. Hrycak and D. T. Lee of the Newark College of Engineering. J. W. Gauntner and J. N. B. Livingood at the NASA Lewis Research Center also participated in the development. Engineering data needed for design is now available in two government reports:

1. NASA-TN-D-5652(N70-18963). "Survey of Literature of Flow Characteristics of Submerged Incompressible Turbulent Jets Impinging on a Flat Plate".
2. NASA-TN-D-5690(N70-20567). "Experimental Flow Characteristics of Submerged Incompressible Turbulent Jets Impinging on a Flat Plate".

These reports are available for \$3.00 each from the National Technical Information Service, Springfield, Virginia 22151.

FROM SPACE AGE RESEARCH

Some products and techniques which were developed to meet complex aerospace problems have possible application in apparel manufacturing. Information on the item announced below is now available from the National Technical Information Service.

THE PROBLEM:

You have an opening, as for a button-hole, in a fabric such as a light weight nylon chiffon or an open-weave stretch material. You need to reinforce the opening to prevent tearing. It may be necessary to provide a strong and stable base for the mounting of snap fasteners in the opening. If you have this type of problem, then the technique described below may prove useful.

THE SOLUTION:

A plastic film, typically a heat-sealable urethane, is applied to each side of the fabric. The two films are then fused together with conventional heat-sealing equipment. The inner area of the fabric is then cut away, leaving a flexible, yet sturdy band of material around the opening with no raw edges.

NOTES:

1. The melting point of the films must be lower than that of the fabrics.
2. For compressible fabrics the cutting die's edge must have a radius

for prevention of burn edges or tear lines.

3. For nylon chiffon 2-mil films of urethane are used with no loss in soft and comfortable feel on the skin.
4. For a stretch fabric 6-mil films of urethane maintain structural integrity of the fabric with only slight loss in comfort.
5. When forming a base for mounting snap fasteners, 8-mil films are applied to round areas slightly greater in diameter than the fasteners.

FOR FURTHER INFORMATION:

This technique was developed under contract to the NASA Manned Spacecraft Center by Ronald J. Bessette of ILC Industries, Inc. Specific questions may be directed to:

Technology Utilization Officer
Manned Spacecraft Center, Code BM7
Houston, Texas 77058
Reference: B70-10489

SPACE AGE DEVELOPMENTS

Some products and techniques which were developed to meet complex aerospace problems have possible application in apparel manufacturing. Information on the item announced below is now available from the National Technical Information Service.

THE PROBLEM:

You need to improve the fire resistance of a garment. The garment contains linings, either to provide warmth or for waterproofing. You wish to avoid treating the linings or using nonflammable materials to reduce costs.

THE SOLUTION:

The lining is enclosed within nonflammable or treated fabric using an edge seam design tested for this purpose. The edge seam and load bearing seam are shown in Figure 1. The stitches are made with a double thread. One thread is Nomex and the other is Beta fiberglass. The Nomex provides strength under normal conditions. The Beta fiberglass thread provides continued protection upon exposure to flame.

FOR FURTHER INFORMATION:

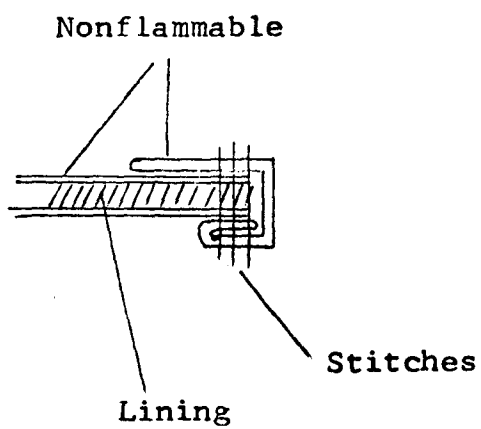
A. D. Little has tested and recommended the above techniques to NASA. They were developed by A. D. Little under Contract NAS 9-7519 with the Manned Spacecraft Center. More detailed information is available in the contract report NASA-CR-101948 entitled, "Development of an Improved Extravehicular

Space Suit Thermal Insulation".

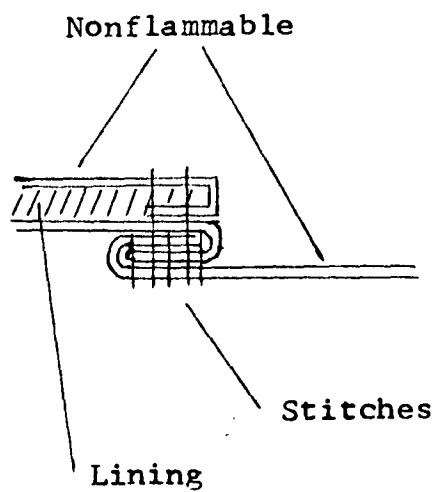
This report may be ordered from:

National Technical Information Service
Springfield, Virginia 22151
Price - \$3.00

FIGURE 1



EDGE SEAM



LOAD BEARING SEAM

SPACE AGE DEVELOPMENTS

The design for a simple electrical switch which can be actuated from any direction is available from NASA. It can be used to turn on a sewing machine or any other electrical equipment and would be particularly convenient for knee or arm operation. The worker pushes against a flexible rod which extends from the switch. The rod can be pushed from any direction. Once it flexes the switch turns on. The position of the worker with respect to the switch is not critical. Thus the worker can operate the machine from her most comfortable position, even though this may vary from one worker to the next. Also the worker can introduce variety into her motions to relieve fatigue.

The switch is simple in design and easily fabricated. It has four basic elements. A flexible reed which conducts electricity is mounted along the axis of a cylinder. The reed extends from one end of the cylinder. This extension is insulated and serves as the flexible rod for actuating the switch. Inside of the cylinder a metal disc is attached to the reed. The reed is mounted through flexible insulators at the ends of the cylinder. When the extended end of the reed is pushed the reed bows inside of the cylinder and the disc makes electrical contact with the inside cylinder wall. One terminal of the switch is connected to the electrically conductive reed. The other terminal of the switch is connected to the cylinder wall. In fabricating the switch a disc size is chosen to provide the desired amount of flexing required for closing the switch. The smaller the clearance between the disc and the

inside cylinder wall, the more sensitive the switch becomes in responding to bending of the extended reed.

Drawings and more detailed information on the switch are available from:

National Technical Information Service
Springfield, Virginia 22151
Price - \$3.00
Reference: TSP69-10032

This invention was made at Hughes Aircraft Co. under contract to NASA. The invention is owned by NASA, and a patent application has been filed. Royalty-free, non-exclusive licenses for its commercial use will be granted by NASA. Inquiries concerning license rights should be made to NASA, Code GP, Washington, D. C. 20546.

SPACE AGE DEVELOPMENTS

If you need to test fabric, fusibles, thread, or seams for flammability, you should investigate a burn-rate testing apparatus developed at the NASA Manned Spacecraft Center. It is easy to mount a one or two inch sample of the material to be tested on the test frame of the apparatus. The test frame can be rotated so that the sample can be tested in any orientation from horizontal to vertical. In some cases orientation can have a marked effect on the rate at which a sample will burn. The test frame is such that small pieces of fabric sewn together could be mounted and tested.

Testing is automatic. The apparatus contains a fuel-oxygen burner and a device for automatic ignition of the burner. To run a test the sample is mounted and the burner is ignited. At this point there is a shutter between the flame and the sample. The shutter keeps the flame away from the sample until the actual test is begun. A thermocouple senses the temperature of the flame. After the flame is automatically ignited the flow of fuel and air to the burner is adjusted so that the flame temperature is at the proper value for the test. The shutter is then removed. A photocell senses the contact of the flame with the fabric and starts an electronic timer. A second photocell senses ignition of the fabric at the point of application of the flame. A third photocell detects the rate at which the fabric burns once it is ignited.

A drawing of the apparatus as developed and used by NASA is shown in Figure 1, Further information is available for anyone interested in building

and using this apparatus. Requests for information may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas
Reference: B69-10740

NASA has filed a patent application on this test apparatus. They will grant a royalty-free, non-exclusive license for its commercial use. Anyone interested in manufacturing the apparatus should contact:

NASA
Code GP
Washington, D. C. 20546

Burn-Rate Testing Apparatus

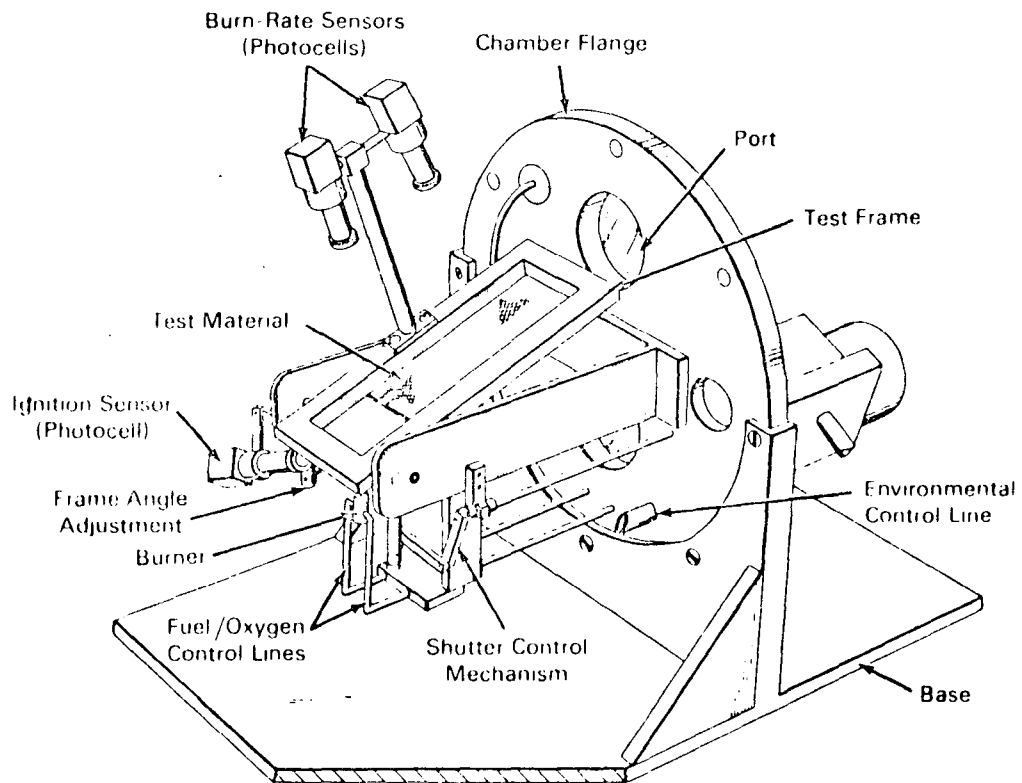


Figure 1. Perspective Drawing of Burn-Rate Test Apparatus

FROM SPACE RESEARCH TO YOU

THE PROBLEM:

Are you concerned with complex production scheduling? Do you need a network flow chart for checking work flow plans? Such a chart would show the movement of work from machine to machine and the time for processing each bundle at each machine. A computer program, VISTA, is now available which automatically draws such charts.

THE SOLUTION:

VISTA can be used by many local computer service organizations serving industry in their area. It requires an IBM 7094 computer and a SC 4020 CRT plotter. You supply data on the time and sequence of the sewing operations for making each garment. The computer then diagrams the necessary work flow on a chart in such a way as to optimize visual analysis. By inspecting the chart you can readily spot machine or operator dead time and make necessary adjustments in the work flow. You can also track down logical flows encountered while establishing the work flow pattern.

NOTES:

To use VISTA you, your consultant, or your computer service bureau should have a basic knowledge of NASA PERT C as outlined in the NASA PERT C Computer Systems Manual, and the Operating Instructions, Launch Systems Branch S-IC NASA/PERT System.

FOR FURTHER INFORMATION:

VISTA was developed by the Boeing Company under contract to Marshall

Space Flight Center. Inquiries for further information may be directed to:

COSMIC
Computer Center
University of Georgia
Athens, Georgia 30601
Reference: B69-10394

FROM SPACE RESEARCH TO YOU

THE PROBLEM:

Do you have a need for rapidly checking incoming fabrics? Are variations in the number of threads per inch important? If so the simple visual inspection apparatus described below could prove useful.

THE SOLUTION:

The apparatus is a light box and a set of photographic negatives. Each negative consists of a set of parallel transparent lines on an opaque background. A specific negative is used to test a specific fabric. The width of the transparent line is equal to the desired diameter of the thread. The number of lines per inch is equal to the desired number of threads per inch in the fabric.

The light box has a translucent diffuser plate as its top to provide uniform illumination. A sample of fabric is placed on top of this plate and clamped in place. The negative is placed on top of the fabric and inserted into two special clamps at the side of the box. These clamps are moved forward and backward with adjustment screws. They allow the negative to be positioned with respect to the fabric.

If the fabric has the desired thread diameter and number of threads per inch and is perfectly uniform, then it is possible to position the negative so that no light shines through. If the number of threads per inch or thread diameter is not correct, then light will shine through. If the lines on the negative are placed at a slight angle to one of the thread directions, then

the light shining through will be in a characteristic pattern. Alternate bands of light zones in a checkerboard pattern and completely dark zones will be seen. The more the thread spacing differs from the desired value, the narrower will be the bands of light and dark zones. Tolerance levels can be set for rejection of fabric. By using different negatives an unknown spacing can be measured.

FOR FURTHER INFORMATION:

The testing apparatus was developed at Marshall Space Flight Center for detecting small variations in flat conductor cable spacing by a quick, visual inspection. It is described in NASA Tech Brief No. 69-10456. Inquiries for further information may be directed to:

Technology Utilization Officer

Marshall Space Flight Center

Huntsville, Alabama 35812

Reference: B69-10456

Inquiries about obtaining rights for the commercial use of the invention may be made to NASA, Code GP, Washington, D.C. 20546.

FROM SPACE RESEARCH TO YOU

A new self-lubricating gear has been developed in the space program. No oil is required. Thus you do not have the maintenance that you do with a normal gear. There is no oil to stain the fabric. Cost is higher, of course. You should consider the gear for particular trouble spots.

The new self-lubricating gear is much stronger and more wear resistant than those made from plastics such as Teflon. It is constructed of alternating layers of metal and a dry lubricating material. A lubricant which has been satisfactory is polytetrafluoroethylene (TFE) reinforced with bronze powder. To make the gear alternate layers of metal and thin layers of lubricant are first bonded into a laminated composite. The gear is then machined from this composite. The machining is done so that the lubricant layers are inclined at an angle with respect to the top and bottom metal surfaces of the gear. Also an odd number of gear teeth is used on one gear of each set. This plus the inclined lubricant layers insures that every spot where the two gears meet receives some lubricant during one revolution.

This gear was developed at Marshall Space Flight Center. Drawings and more detailed information are available from:

National Technical Information Service

Springfield, Virginia 22151

Price - \$3.00

Reference: TSP69-10408

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

FROM SPACE RESEARCH TO YOU

Do you manufacture garments where flammability is important? If so a new synthetic material developed for NASA may be significant to you.

The new material is a polyimide resin which can be fabricated into a number of forms including fibers. The material has thermo-oxidative stability up to 600°F. The material also has excellent mechanical properties such as toughness, flexibility, and a high modulus. The primary improvement over other commercial polyimide resins has been to provide a fully cured resin which is still sufficiently soluble in organic solvents that it can be processed into fibers.

Fibers represent only one of many applications for the material and to the best of our knowledge are not yet commercially available. The developers are H. R. Lubowitz and R. J. Jones, TRW Systems Group, One Space Park, Redondo Beach, California 90278.

FROM SPACE RESEARCH TO YOU

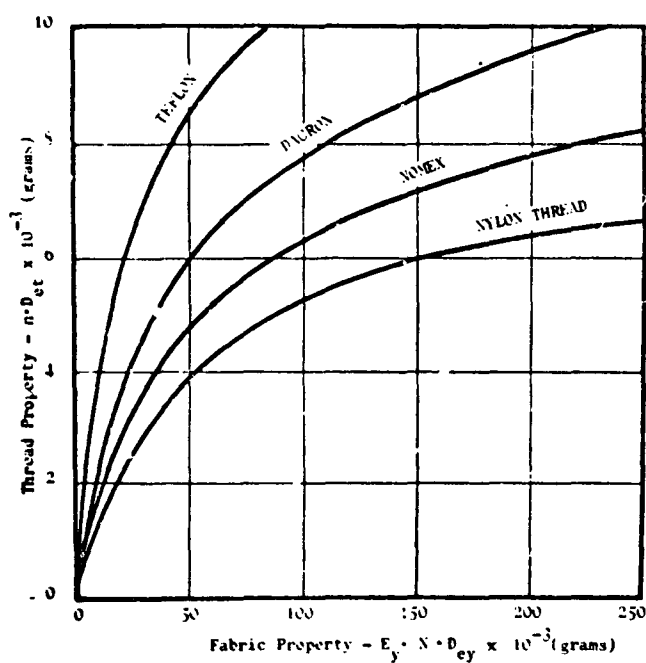
Details of garment design are a matter of style and are subjective. In design, however, there are always certain minimum requirements such as minimum seam strength. The resulting number of stitches required can vary considerably from one seam to the next. Do you take full advantage of this in your design?

With the attached chart you can determine how many stitches are required from a strictly engineering viewpoint. This chart was prepared for NASA to aid them in determining garment selection criteria. The minimum number of stitches/inch referred to in the chart is the minimum number required for the strength of the stitches to be equal or greater than that of the fabric joined. The minimum number of stitches/inch is related to thread strength, fabric yarn properties, and pick or end density.

For further information you can obtain the "Handbook of Garment Selection Criteria For a Space Station" (N70-15022) from the National Technical Information Service, Springfield, Virginia 22151. This handbook was prepared for the National Aeronautics and Space Administration by Austin C. Morris, B. Welton & Co., Inc., Hartford, Connecticut.

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FIGURE 2-9. STITCH NUMBER SELECTION



where:

- N = Pick or end density - yarns/inch
- E_y = Fabric yarn ultimate strength - grams/denier
- D_y = Fabric yarn denier
- D_{ey} = Thread denier
- n_{et} = Minimum number of stitches/inch

Reference Data; 2

FROM SPACE RESEARCH TO YOU

THE PROBLEM:

You require fabrics with improved fireproof characteristics.

THE SOLUTION:

A chemical treatment has been developed for aromatic polyamide fabrics which will render them fireproof even in a pure oxygen atmosphere.

The treatment consists of two steps. First the fabric is reacted under controlled conditions with the vapors from a solution containing equal parts by weight of phosphorous oxychloride and phosphorous oxybromide. In the second step the fabric is reacted with bromine vapor. The surface of the treated material is then neutralized.

NOTES:

This process was applied to a proprietary, flexible aromatic polyamide fabric that was fireproof in air but not in pure oxygen. After treatment the fabric passed the standard tissue paper ignition test on a folded edge in pure oxygen at a pressure of 6.2 psia.

Flame resistance could be improved even further by soaking the treated fabric in an aqueous suspension of ammonium polyphosphates. These polyphosphates are leached out, however, when the fabric is washed in water-detergent solutions.

FOR FURTHER INFORMATION:

The vapor treatment was developed under contract to NASA by the Monsanto Research Corporation. Inquiries for further information may be directed to:

Technology Utilization Officer

Manned Spacecraft Center, Code BM 7

Houston, Texas 77058

Reference: B70-10540

FROM SPACE RESEARCH TO YOU

Are you manufacturing apparel which must provide a certain minimum warmth and yet retain style? If so, some work done for NASA on garment selection criteria may be of use.

Certain regions of the body are much more responsive to protection than others in providing warmth. Drape can have a marked effect on the insulation properties of clothing. The specific fabric and weave, of course, are significant. Fabric porosity and dew point together also control the natural body cooling processes. All of these factors have been analysed quantitatively for NASA. Examples of the resulting data are attached to this announcement in graphical form. There are many variables which affect the total insulation provided by a garment. There are thus many alternative designs for a garment which will provide the same warmth. The graphs prepared for NASA allow you to quantitatively assess the insulation properties of any one of these alternative designs.

The graphs fall into three distinct categories. First there is data on the total body insulation required for comfort under various conditions. Second there is information on the insulation requirements for specific parts of the body consistent with a given total requirement. Third there is information on the insulative properties of garments as a function of such variables as drape, weave, and fabric material.

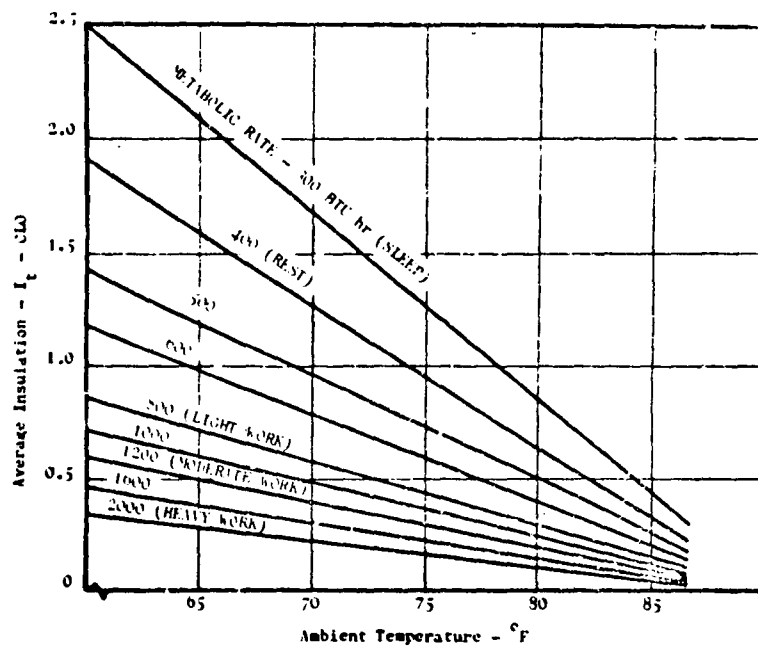
Once the total requirement is determined from Figure 1-3 then the local insulation requirement can be determined by Figure 1-4. The remaining charts

may then be used to determine the effective insulation for a particular garment design. First Figure 1-7 is used to determine the insulation properties of the material. Then Figure 1-8 is used to introduce the effect of drape.

For further information you can obtain the "Handbook of Garment Selection Criteria For A Space Station" (N70-15022) from the National Technical Information Service, Springfield, Virginia 22151. This handbook was prepared for the National Aeronautics and Space Administration by Austin C. Morris, B. Welson & Co., Inc., Hartford, Connecticut.

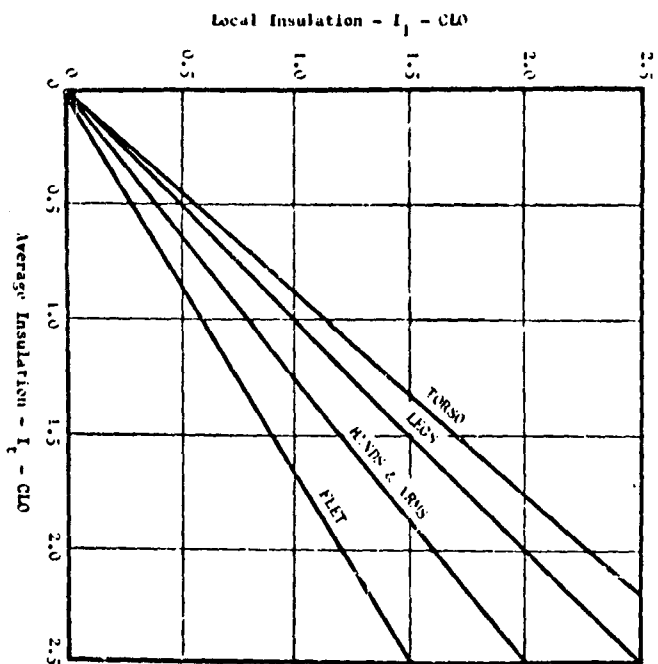
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FIGURE 1-7 TOTAL BODY INSULATION REQUIRED FOR COMFORT



Typical Insulation Values

<u>Article</u>	<u>Insulation</u>
Nude	0.5, (due to air insulation)
Flight Coveralls with cotton underwear	1.0
Flight Coveralls with woolen underwear	2.0



Metabolic Range - 500 - 800 BTU/hr

FIGURE 1-4 LOCAL INSULATION REQUIREMENTS

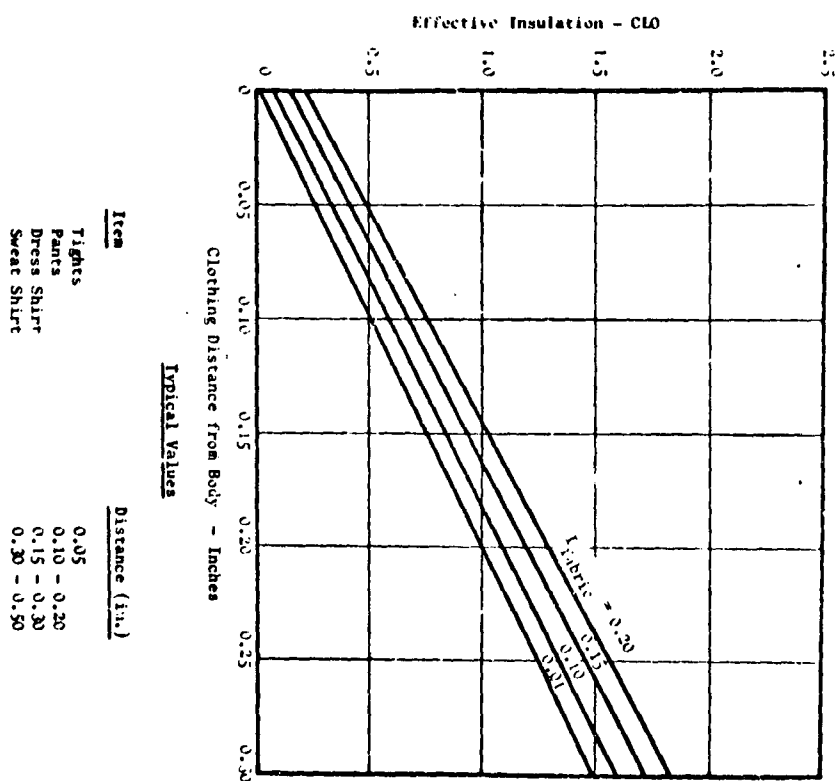
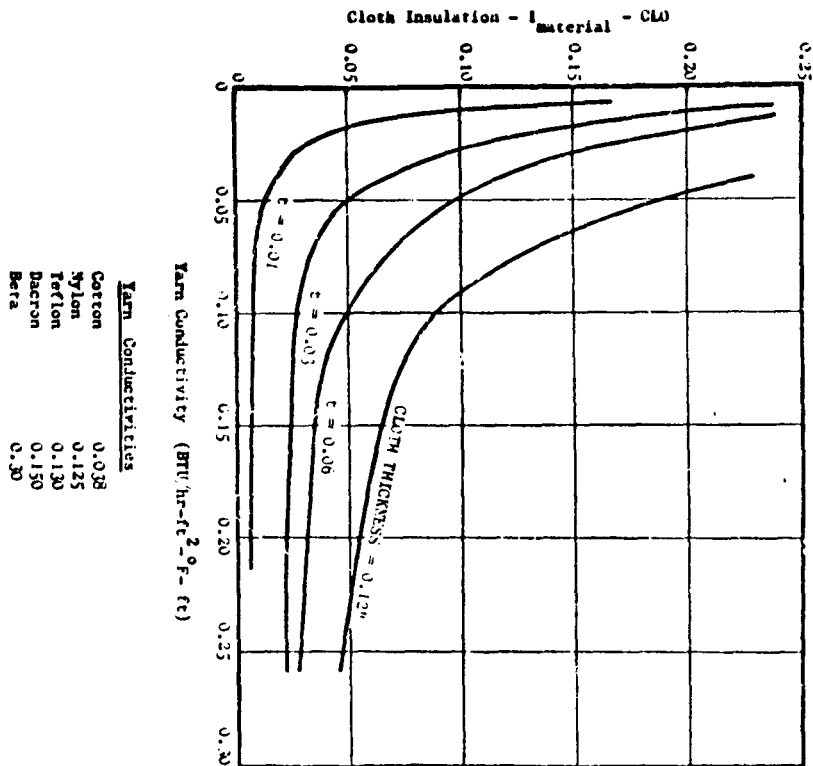


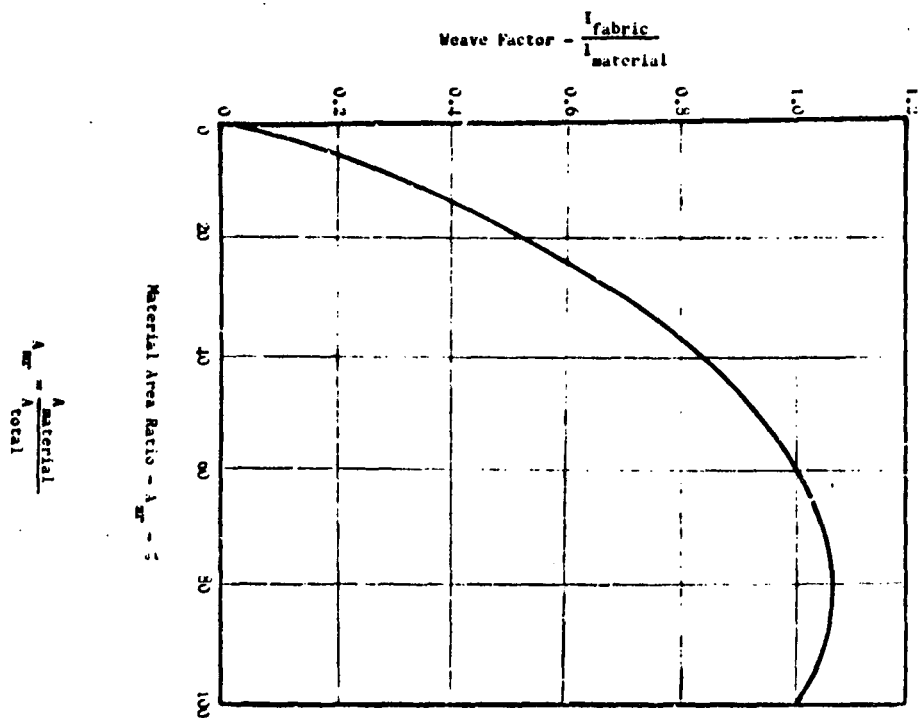
FIGURE 1-5 EFFECT OF WRAPS UPON CLOTHING INSULATION

FIGURE 1-2 MATERIAL INSULATION PROPERTIES



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FIGURE 1-3 WAVE LENGTH (WV) MATERIAL INSULATION



FROM SPACE RESEARCH TO YOU

Are you looking for a way to treat garments to improve their fire resistance? Is the flexibility of the treated fabric important? If so you may have an interest in some NASA developed treatments for various fabrics which meet these requirements.

One such treatment consisted of applying a coating of ammonium polyphosphate and then a second coating of ammonium dihydrogen phosphate-filled 55-durometer Fluorel L-3583-2. This was done with Celanese PBI and Monsanto X-400. Both were sufficiently improved in flame resistance to pass the 6.2 psia 100% oxygen silicone igniter test. The treated fabric was resistant to abrasion and the coating did not peel with repeated flexing of the fabric.

A non-coating treatment was also developed for Celanese PBI. The fabric was actually reacted with phosphorus oxychloride vapor in the presence of oxygen. This treatment not only imparted flame resistance to the fabric but was also durable. It was developed for NASA by the Dynatech Corporation in Cambridge, Massachusetts, and the latter firm considered it one of their most significant accomplishments.

Further information may be obtained from Dynatech's final contract report, "Development of Fireproof Coating Materials", NASA-CR-108274. This may be ordered from:

National Technical Information Service
Springfield, Virginia 22151
Reference: N70-21269

FROM SPACE RESEARCH TO YOU

Do you need to design garments with liners that can be readily removed? Would you like to enclose water-proofing or other material between the outer and inner part of a garment and yet be able to readily remove this material when the garment was cleaned? If so, one of the techniques used by NASA in space suit assembly may be of interest.

This particular space suit was designed for intravehicular activity. It was necessary to encase a bladder between an inner liner and an outer flame resistant garment. This was done with a combination of velcro stripping and snap fasteners. White nylon velcro stripping was used to completely encase the bladder suit between the inner and outer garments. The stripping was placed along the frontal location of both the inner comfort liner and the outer restraint garment. Stripping was also placed around the neck, wrists, and ankles of both garments. The bladder suit is held in place within the two garments by a few commercial snap fasteners in strategic locations.

This suit was developed for NASA by the Garrett Airesearch Manufacturing Company. Further information can be obtained from their final contract report. This may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Reference: N70-20683

FROM SPACE RESEARCH TO YOU

In a particular garment the choice of fabric can depend on functional use as well as style and appearance. There are many physical properties of fabrics which relate to functional use. Flammability can be significant in some cases. Moisture regain, the amount of water that a fabric can absorb, is one of the most important factors in garment comfort. Water compatibility and fabric shrinkage is another factor that often must be considered. Some physical properties of fabrics also relate to style and appearance. For example, the wrinkle resistance of a garment is related to the elastic recovery properties of the material. If these factors are significant in your case, then the graphs attached to this announcement may be of value to you.

All of the above factors have been analyzed quantitatively for NASA. Some of the results are presented in the accompanying graphs. These graphs show the relative suitability of different fabric materials for each of the factors mentioned above. For each garment the choice of material would depend on optimizing those characteristics that are the most pertinent for that particular garment.

Figure 3-2 compares the flammability of a number of different fabric materials. The charts in this figure compare flammabilities in mixtures of oxygen and nitrogen. There are two charts corresponding to oxygen partial pressures of 2.7 psia and 3.5 psia. (The partial pressure of oxygen in air at sea level is approximately 3 psia). For each material the charts

show the total combined pressure of oxygen and nitrogen for which that material has a standard burning rate. The more nitrogen that must be mixed with the oxygen to reduce burning rate to the standard the more flammable is the material. Thus the greater the total pressure in the chart the more flammable is the material. Of the materials compared, cotton is the most flammable and fiberglass is the least.

In Figure 3-3 the moisture regain characteristics of various fabrics are shown. "Moisture regain" is the percent weight of water that a fabric may hold by absorption per unit fabric weight. This characteristic determines the ability of a fabric to hold perspiration without a "wet" sensation.

Table 3-3 compares the water compatibility of a number of fabric materials. For hygroscopic materials the greater the increase in fiber diameter upon water absorption the greater the tendency for the fabric to shrink.

The wrinkle/shape recovery of a garment is related to the elastic properties of the fibers. If a fiber is stressed so that the initial strain exceeds the elastic limit and then the stress is removed, the fiber does not fully return to its original dimensions. The percent recovery of the fiber is plotted against initial strain in Figure 3-6. The greater the percent recovery for a given initial strain the greater will be the resistance of the fabric to wrinkling.

For further information you can obtain the "Handbook of Garment Selection Criteria To a Space Station" (N70-15022) from the National Technical Information Service, Springfield, Virginia 22151. This handbook was prepared for the National Aeronautics and Space Administration by Austin C. Morris, B. Welton & Company, Inc., Hartford, Connecticut.

TABLE 3-3 FIBER SWELLING DUE TO LOW TEMPERATURE WATER EXPOSURE

<u>MATERIAL</u>	<u>TYPE</u>	<u>LENGTH CHANGE</u>	<u>DIAMETER CHANGE</u>
Cotton, Raw	Hygroscopic	1.2%	14 - 30%
Cotton, Mercerized	Hygroscopic	0.1%	20%
Glass	Hydroscopic	0%	0%
Nylon	Partially Hygroscopic	1.2%	1.9 - 2.6%
Nomex	Partially Hygroscopic	1.2+%	3.0%
Dacron	Partially Hygroscopic	0 - 0.1%	0 - 0.3%
Teflon	Hydroscopic	0%	0%

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FIGURE 7-2 MATERIAL FLAMMABILITY COMPARISON

(Points of Equal Flammability)

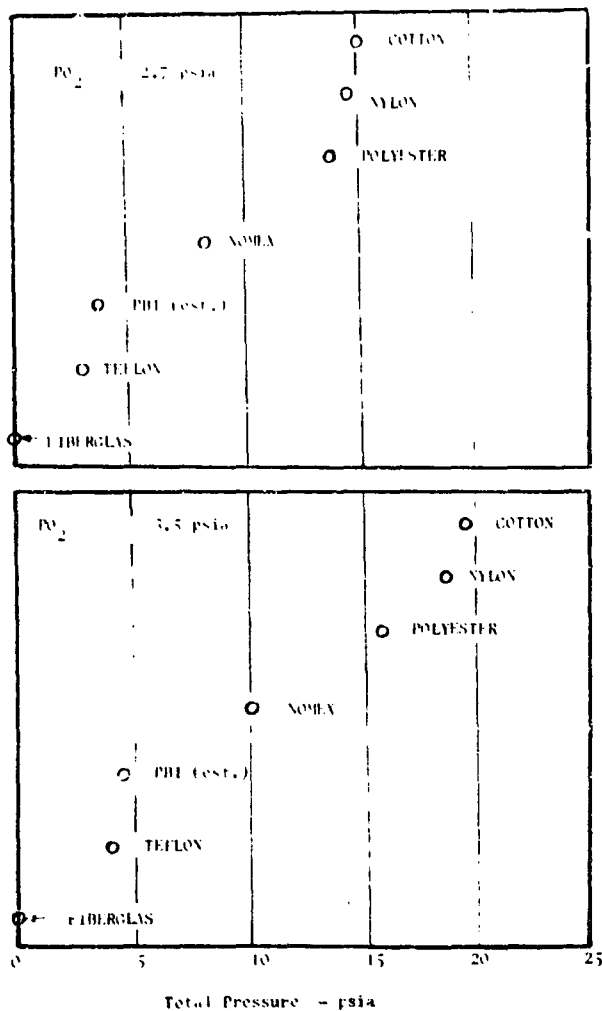


FIGURE 3-3 MOISTURE GAIN CHARACTERISTICS

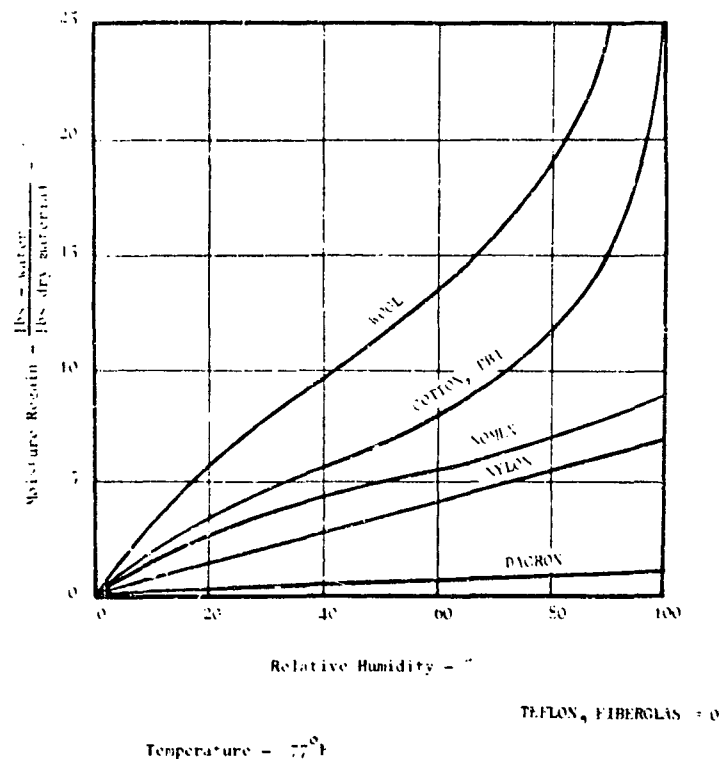
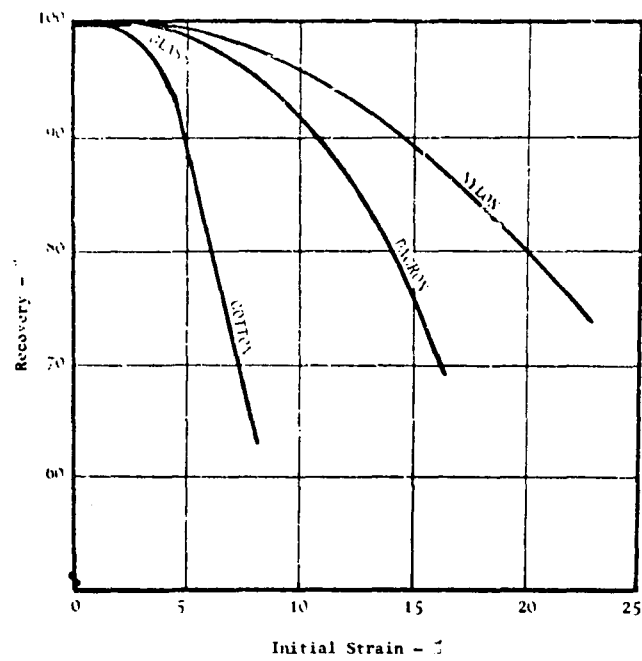


FIGURE 3-b FIBER ELASTIC RECOVERY



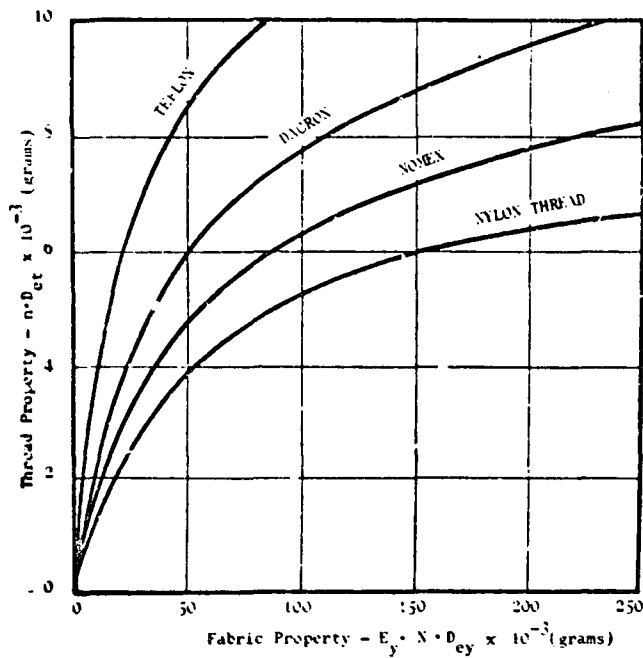
FROM SPACE RESEARCH TO YOU

Details of garment design are a matter of style and are subjective. In design, however, there are always certain other requirements such as optimizing seam strength. Strength is often desirable but it is also necessary for the seam to be designed so that it breaks before the fabric. The resulting maximum number of stitches allowed can vary considerably from one seam to the next. Do you take full advantage of this in your design?

With the attached chart you can determine how many stitches are allowed from a strictly engineering viewpoint. This chart was prepared for NASA to aid them in determining garment selection criteria. The maximum number of stitches/inch referred to in the chart is the maximum number allowed for the strength of the stitches to be equal or less than that of the fabric joined. The maximum number of stitches/inch is related to thread strength, fabric yarn properties, and pick or end density.

For further information you can obtain the "Handbook of Garment Selection Criteria For a Space Station" (N70-15022) from the National Technical Information Service, Springfield, Virginia 22151. This handbook was prepared for the National Aeronautics and Space Administration by Austin C. Morris, B. Welton & Co., Inc., Hartford, Connecticut.

FIGURE 2-c STITCH NUMBER SELECTION



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where:

- N = Pick or end density - yarns/inch
- E_y = Fabric yarn ultimate strength - grams/denier
- D_y = Fabric yarn denier
- D_{ey} = Thread denier
- n_{et} = Minimum number of stitches/inch

Reference Data; 2

FROM SPACE RESEARCH TO YOU

THE PROBLEM:

In cutting fabric you sometimes have difficulty in keeping all plies aligned. Suppose a stack of fabric pieces has been cut out and is now being trimmed. There has been a shift in the stack so that one edge is at an angle with respect to the edge being cut.

THE SOLUTION:

A NASA employee has invented an adjustable cutting guide which aligns stacks of material. This guide is illustrated in the attached drawing. With the threaded pin loosened, the angle between arm 1 and arm 2 is adjusted to match one of the corners of the stack of fabric. The threaded pin is then tightened, and the fabric is aligned against these arms for further cutting. The circular base and backstop provide flexibility in positioning the stack on the cutting table. Although the device is generally applicable to a number of materials, NASA has specifically suggested its application to fabrics.

NOTES:

For further information inquiries can be directed to:

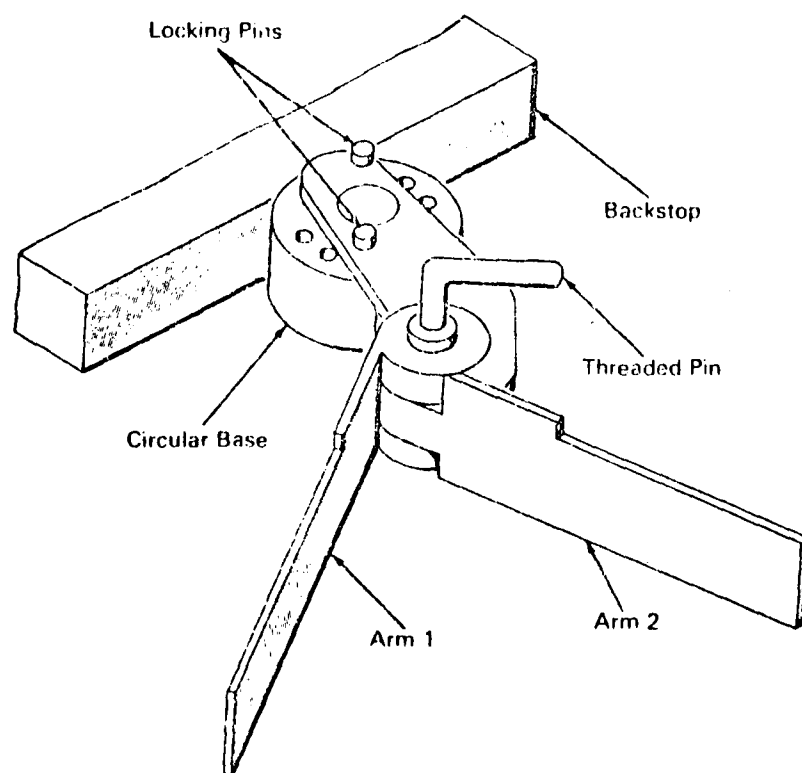
Technology Utilization Officer

Manned Spacecraft Center

Houston, Texas 77058

Reference: B66-10210

Adjustable Cutting Guide Aligns and Positions Stacks of Material



FROM SPACE RESEARCH TO YOU

THE PROBLEM:

You need to improve the fire resistance of your garments. You use adhesives in your manufacturing and these have an effect on garment fire resistance.

THE SOLUTION:

NASA has developed a series of nonflammable adhesives. This work was done by the Whittaker Corporation in San Diego, California under contract to the NASA Manned Spacecraft Center. The adhesives are based on polyurethanes prepared from polyethers of perfluoropropylene oxide. The adhesives are self-extinguishing in oxygen-rich atmospheres.

Further information, including methods of preparing typical adhesives as well as pressure sensitive adhesive tape, is available in the NASA contract report. This may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Reference: NASA-CR-102176 (N70-18706)